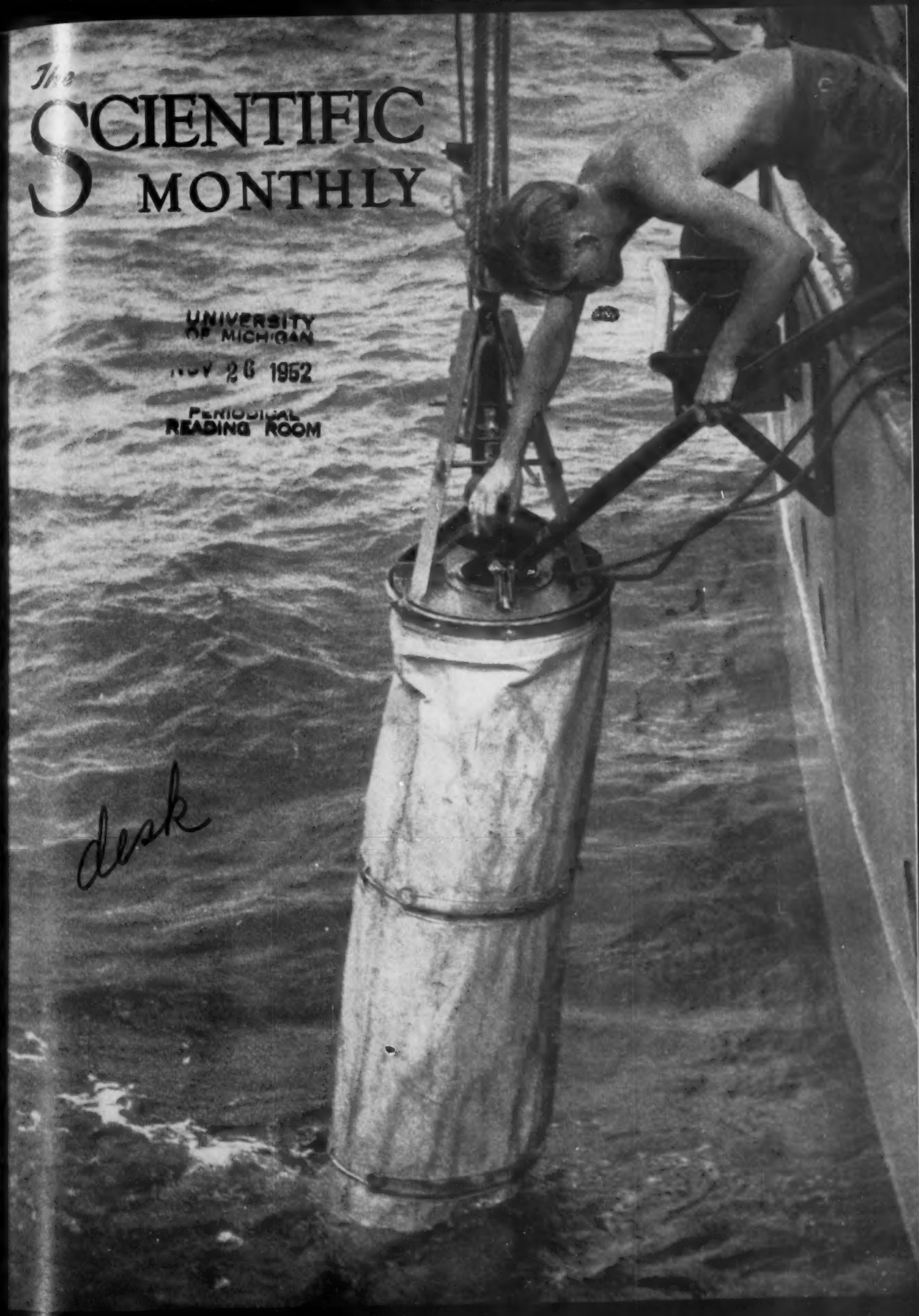
The SCIENTIFIC MONTHLY



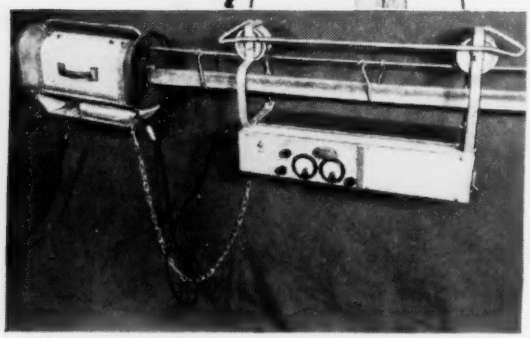
UNIVERSITY OF MICHIGAN
NOV 26 1952
PERIODICAL READING ROOM

desk

VOL. LXXV NO. 5 NOVEMBER 1952

This electronic nose sniffs out leaks

Starting electronic nose on its way. It is pulled from pole to pole by line extending toward the ground. Previously workmen had to paint the cable with soap solution, so bubbles would disclose leaks.



For test, the cable is cleared of protective nitrogen or air, and filled with Freon gas. Case at left collects escaping gas which operates Freon-sensitive detector underneath. At points where Freon escapes through sheath cracks, the box at right—a combined control unit and power supply—rings a bell. Workmen mark the point of leak for later repair.

After years of buffeting by the wind, even tough telephone cable sometimes shows its age. Here and there the lead sheath may crack from fatigue or wear through at support points. Before moisture can enter to damage vital insulation, leaks must be located and sealed.

To speed detection, scientists at Bell Laboratories constructed an electronic nose which *sniffs* out the leaks. Using an electrically operated element developed by the General Electric Company, the device detects leaks of as little as 1/100 cubic foot per day. Sheath inspection can be stepped up to 120 feet per minute.

Thus Bell scientists add findings in other fields to their own original research in ways to make your telephone system serve you better. On the other hand their discoveries are often used by other industries. Sharing of scientific information adds greatly to the over-all scientific and technological strength of America.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields

THE SCIENTIFIC MONTHLY

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GLADYS M. KEENER, Executive Editor

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Science and Technology

(From the Month's News Releases)

Oh, Every Year Hath Its Winter

If you fuss with the room thermostat all winter long in an attempt to keep the house comfortable, take a look at its location. If cold air from windows or doors, or warm air from a register, radiator, or fireplace flows over the thermostat, it may fail to maintain a comfortable temperature. Heat from a wall heated by hot water pipes, warm air ducts, or a chimney will affect its operation. Even the heat from a nearby lamp, television set, or radio will reduce thermostat efficiency. To use a room thermostat properly, the temperature setting should be raised or lowered only one degree at a time until the most comfortable temperature is reached. A high setting will not raise the temperature to the desired point any faster; similarly, setting the dial at the bottom of the scale will not cool the house any faster.

A rubber mat with a built-in radiant heating unit operates on standard 110-volt current and may be used in theatres, hotels, warehouses, police and toll booths, and under the feet of machine operators who must stand in cold areas for long periods of time.

A table model humidifier evaporates more than three gallons of water per 24-hour day, enough to moisten the air of three or four average-sized rooms. It can be used with any type of heating .

Plastic storm windows and doors withstand rain and snow and are unaffected by temperatures down to −60°. Much less expensive than the usual storm windows, they may be used where standard sizes will not fit. An aluminum screen door cover will transform screen doors into storm doors quickly and economically. Because they are made of aluminum foil, anyone who can use a hammer and scissors can put them up. With reasonable care, the manufacturer claims, the doors will give several seasons' protection.

If static electricity is a problem, a chemical-impregnated cloth that comes in 18″ × 18″ squares or in any desired length, 36″ wide, will remove static charges and prevent their recurrence on such materials as plastics, synthetic and natural rubbers, and synthetic fabrics. If kept free from dirt the cloth can be used indefinitely. Treated materials can be washed with soaps or detergents without losing their antistatic qualities.

It's New!

The New York State Agricultural Experiment Station has introduced a new type of juice made from white grapes, processed like apple juice. The operation involves the addition of ascorbic acid to the grapes after stemming but just before crushing. The grapes are then pressed and pasteurized rapidly. The addition of ascorbic acid checks oxidation and adds to the nutritive value, and the grape juice made by the new process has an attractive color, is quite stable, with little sediment, and has an excellent flavor.

Electronic Engraver

Weekly newspapers and job printing shops may now employ the services of Fairchild Camera and Instrument Corporation's Scan-a-graver Cadet, a table-top machine that makes an 85-screen four-column plastic halftone in 24 minutes. The Cadet will be leased under a special arrangement by which Fairchild will install the machine and train operators.

Disinfectant and Bactericide

Movidyn, first manufactured in Czechoslovakia for the disinfection of private water supplies and swimming pools and for use in such industries as dairies, bakeries, breweries, and wineries, is now commercially available in the United States. Tasteless, nonpoisonous, noncorrosive, it is a stable colloidal solution, and it is claimed that less than 1 part in ten million will sterilize water and inhibit the growth of algae, fungus, and mold. Containers, tanks, pipelines, and other surfaces that have been in contact with water treated with Movidyn become, in themselves, sterilizing agents. Used as a wash, it will leave the surface of fruits and vegetables sterile, thus preventing spoilage.

Road Test

South of Malad, Idaho, the Highway Research Board is making tests of controlled truck traffic, sponsored by the highway departments of 11 Western states, in cooperation with the Bureau of Public Roads, the Automobile Manufacturers' Association, the Truck Trailer Manufacturers' Association, and the petroleum industry. Test sections which will later be incorporated into a relocation of U. S. Route 191 were built under rigid construction control, and in this way it will be possible to compare the relative effects of different truck loads on different thicknesses of road materials. The pavement of the "WASHO" project is in the form of two loops, one of which will be tested under trucks with tandem axles and one under single-axle trucks. Instruments installed in the pavement will measure effects of different loads, and the visible damage, if any, will be carefully studied. Regular tests, consisting of 18 hours of truck traffic per day, six days per week, began early in November, and by the fall of 1953 each test section will have been subjected to over 200,000 heavy axle loads.

Lost a Cow?

A noseprint system has been developed for the positive indentification of dairy cows. At the South Dakota Agricultural Experiment Station, three researchers, working in cooperation with FBI fingerprint experts, have worked out a method of classifying bovine

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Address a post card to Science and Technology, 1515 Massachusetts Ave., N.W., Washington 5, D. C., for further information about any item on pages iv and v.

noseprints and have so far been able to classify the noseprints of any breed into any one of 5832 different groups.

All Made of Plastic

All-purpose plastic pockets that fit standard two-, three-, and five-ring binders with zipper openings at the outer edge, are inexpensive and are available at department, book, stationery, and variety stores.

Rigid plastic label holders for post binders will lock on any size post from ⅛″ to ½″ in diameter, and are made in three sizes. A label typed on paper is inserted in the frame to be attached to the open back of the binder.

Two quick calculators in disk form will figure advance dates or the volume of a package from its dimensions in inches. The date-finder comes in two sizes: one for calculating future dates by number of weeks and a larger one for figuring either by weeks or by days.

Wheeled Bag

A durable canvas shopping cart on two rubber-tired wheels folds into a neat carrying case only 18 inches long and weighing only 3 pounds; open, it measures 6″ × 16″ × 25″. Metal parts are rust-resistant.

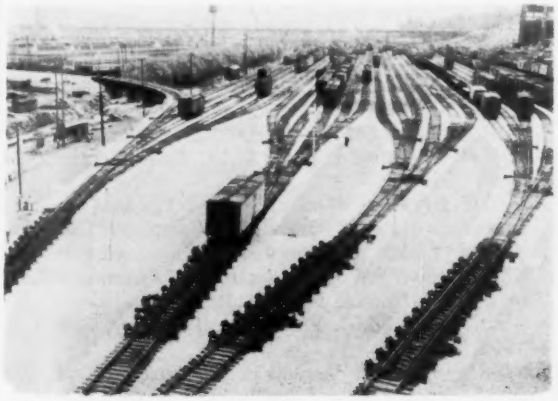
New Journals Received

The British Journal of Delinquency. Official organ of the Institute for the Study and Treatment of Delinquency. Quarterly; Vol. I, No. 1, Oct. 1950. $4.25 per year, from the institute, 8 Bourdon St., Davies St., London, W. 1. . . . *Building Research in Canada.* Division of Building Research, National Research Council, Ottawa, Canada. Vol. 1, No. 1, June 30, 1951. . . . *Bulletin, Centre Roumain de Recherches* (French) Quarterly; Vol. I, No. 2, Feb. 1952 (mimeo.). 50¢ per copy, U.S. 28, rue Serpente, Paris 6e. . . . *La Clinica Terapeutica* (Italian). Monthly; Vol. 2, No. 1, Jan. 1952. 3000 lire. Societa' Editrice Universo, Viale Università, N. 27, Rome. . . . *Czechoslovak Journal of Physics.* Vol. I, No. 1, Oct. 1, 1952. Centre of Research and Technical Development–Central Institute of Physics, Prague. . . . *Hiroshima Journal of Medical Sciences.* Vol. 1, No. 1, Dec. 1951. Hiroshima Medical College, Aga-Machi, Kure-City, Hiroshima-Prefecture, Japan. . . . *The Indian Journal of Child Health.* Monthly; Vol. I, No. 3, March 1952. Rs. 15, foreign. The Association of Pediatricians of India, Back-Bay View, New Queen's Road, Bombay 4. . . . *Instrument Engineer.* Devoted to measurement and automatic control in industry. Semiannual; Vol. 1, No. 1, April 1952. 5*s.* per year. George Kent Ltd., Luton, Bedfordshire, Eng. . . . *Japanese Journal of Ichthyology* (Japanese, with English abstracts). Bimonthly; Vol. I, No. 1, August 20, 1950. $4.50. Japanese Society of Ichthyologists. Publishing office: Nippon Gyogaku Shinko Kai, Tsukiji, 5-chōme, 1-banchi, Kyobashi, Tokyo. . . . *Revista Chilena de Entomología* (uses language of its writers). Facultad de Filosofía y Educación (Universidad de Chile) y de la Sociedad Chilena de Entomologiá. Vol. 1, 1951. $3.50 US. . . . *Scientific Papers of the College of General Education, University of Tokyo.* Semiannual; Vol. 1, No. 1, Oct. 1951. . . . *Tlatoani* (Spanish). *Boletin de la Sociedad de Alumnos de la Escuela Nacional de Antropologia e Historia, México, D. F.* Bimonthly; Vol. I, No. 2, March–April 1952. $1.50 US. . . . *Transactions of the American College of Cardiology.* Vol. I, 1951. Publication Committee: 140 W. 57th St., New York 19.

Filters

A polyethylene squeezable bottle in 6-, 8-, or 16-ounce sizes produces pure water from tap water at the rate of six ounces per minute. Prices range from $1.75 to $3.00, and filter refills are $1.25 to $2.25.

Another simple and inexpensive filter unit may be attached to the kitchen tap and allowed to drain into a Mason jar or even a milk bottle. A pint of mineral-free water is filtered in four to five minutes.



Air Line Yard of the Milwaukee Road in Milwaukee, Wisconsin, first classification yard to employ both automatic switching and retarder speed control. Left, eight "cuts" of cars make their way automatically to proper tracks at predetermined speeds. Right, operator sitting on third floor of control tower, where he can see the crest of the gravity yard, the retarders and the switches, and all 25 tracks, pushes one button to route a car to any track, another to govern its speed. Lighted numbers in the panel attached to the back of the console permit him to see how he has set up in advance the routes for the next five consecutive groups of cars to be switched.

New Books Received

The Tree of Human History. Alan Houghton Brodrick. 253 pp. $4.75. Illus. Philosophical Library, New York. 1952.

Biology: Its Human Implications. (2nd ed.) Garrett Hardin. xii + 720 pp. Illus. $5.00. Freeman, San Francisco. 1952.

Principles of Human Relations. Norman R. F. Maier. ix + 474 pp. $6.00. Wiley, New York; Chapman & Hall, London. 1952.

The Practical Significance of Modern Cardiological Investigations. T. E. Lowe, H. B. Kay, and H. A. Luke. 206 pp. Illus. $7.50. Melbourne University Press, Melbourne; Cambridge University Press, New York. 1952.

Corrosion Testing Procedures. F. A. Chapman. xi + 361 pp. Illus. $6.25. Wiley, New York. 1952.

The Physical Principles of Thermodynamics. R. A. Smith. xiii + 280 pp. Illus. 30s. Chapman & Hall, London. 1952.

The Human Pelvis. Carl G. Francis. 210 pp. Illus. $5.00. Mosby, St. Louis. 1952.

Dictionary of Architecture. Henry H. Saylor. xi + 221 pp. Illus. $4.50. Wiley, New York; Chapman & Hall, London. 1952.

Journal of Researches. (Facsimile repr. of 1st ed., 1839). Charles Darwin. xiv + 615 pp. + 20 plates. $7.50. Hafner Pub., New York and London. 1952.

Geology. O. D. von Engeln and Kenneth E. Caster. xii + 730 pp. Illus. $7.00. McGraw-Hill, New York. 1952.

The Shoals of Capricorn. F. D. Ommanney. 322 pp. Illus. $4.00. Harcourt, Brace, New York. 1952.

The Tundra World. Theodora C. Stanwell-Fletcher. xiii + 266 pp. Illus. $3.50. Little, Brown, Boston. 1952.

The Tertiary Cheilostomatous Polyzoa of New Zealand. David Alexander Brown. xii + 405 pp. Illus. £4, 10s. British Museum (Natural History), London. 1952.

Gmelins Handbuch der anorganischen Chemie. (8th ed.) *Titan,* Syst. #41. xxii + 481 pp. Illus. $27.20. Verlag Chemie, Weinheim-Bergstrasse. 1951.

Gmelins Handbuch der anorganischen Chemie. (8th ed.) *Arsen,* Syst. #17. xv + 475 pp. Illus. $33.33. *Sauerstoff,* Pt. 2, Syst. #3. iv + 218 pp. Illus. $15.48. *Magnesium,* Pt. A4, Syst. #27. xviii + 336 pp. Illus. $23.81. Verlag Chemie, Weinheim-Bergstrasse. 1952.

Renal Function. Transactions of the Third Conference Oct. 18–19, 1951, New York. Stanley E. Bradley, Ed. 210 pp. Illus. $3.50. Josiah Macy, Jr. Foundation, New York. 1952.

Adrenal Cortex. Transactions of the Third Conference Nov. 15–16, 1951, New York. Elaine P. Ralli, Ed. 204 pp. Illus. $3.25. Josiah Macy, Jr. Foundation, New York. 1952.

Collected Papers of the Mayo Clinic and the Mayo Foundation, 1951, Vol. XLIII. x + 833 pp. $12.00. Illus. Saunders, Philadelphia and London. 1952.

Education and the Spirit of the Age. Series of lectures at Queens University, Canada. Sir Richard Livingstone. viii + 113 pp. $2.00. Oxford University Press, London. 1952.

A Hundred Years of Anthropology. (Rev. ed.) T. K. Penniman. 512 pp. $5.00. Duckworth & Co., London. 1952.

Childhood Experience and Personal Destiny. William V. Silverberg. xi + 289 pp. $4.50. Springer Pub., New York. 1952.

The Electromagnetic Field. Max Mason and Warren Weaver. xiii + 390 pp. $3.95, clothbound; $1.85, paperbound. Illus. Dover Pub., New York. 1952.

Mechanics of the Gyroscope: The Dynamics of Rotation. (2nd ed.) Richard F. Deimel. lx + 192 pp. $3.00, clothbound; $1.60, paperbound. Illus. Dover Pub., New York. 1952.

Opticks. (Based on 4th ed., 1730.) Sir Isaac Newton. cx + 406 pp. $3.95, clothbound; $1.90, paperbound. Illus. Dover Pub., New York. 1952.

Polarized Light in Metallography. G. K. T. Conn and F. J. Bradshaw. xi + 130 pp. $3.80. Illus. Academic Press, New York; Butterworth Scientific Pub., London. 1952.

Quantitative Analysis. Andrew Patterson, Jr., and Henry C. Thomas. xii + 500 pp. $4.25. Illus. Holt, New York. 1952.

Quantitative Chemical Analysis. Charles W. Foulk, Harvey W. Moyer, and William M. MacNevin. x + 484 pp. $5.00. Illus. McGraw-Hill, New York. 1952.

The Basic Aspects of Radiation Effects on Living Systems. Symposium on Radiobiology. Oberlin College June 14–18, 1950. James J. Nickson, Ed. xii + 465 pp. $7.50. Illus. Wiley, New York. 1952.

The Science of Biology. (4th ed.) William C. Beaver. 895 pp. $5.85. Illus. Mosby, St. Louis. 1952.

Genes and Mutations: Cold Spring Harbor Symposia on Quantitative Biology. Vol. XVI. xvi + 521 pp. $9.00. Illus. Biological Laboratory, Cold Spring Harbor, N. Y. 1951.

Schwerkraft und Weltall. Pascual Jordan. viii + 208 pp. $5.00. Friedr. Vieweg & Sohn, Braunschweig. 1952.

The Clinical Application of Antibiotics (Penicillin). M. E. Florey. xiii + 730 pp. $17.50. Illus. Oxford University Press, New York. 1952.

Physical Diagnosis. Harry Walker. 461 pp. $8.00. Illus. Mosby, St. Louis. 1952.

Culdoscopy. American Monograph Series. Albert Decker. xv + 145 pp. $3.50. Illus. Saunders, Philadelphia and London. 1952.

A Brief History of Entomology. Herbert Osborn. iii + 303 pp. + 58 plates. $4.50. Spahr & Glenn, Columbus, Ohio. 1952.

Mental Prodigies. Fred Barlow. 256 pp. $4.75. Philosophical Library, New York. 1952.

Case Record from a Sonnetorium. Edward St. John Gorey and Merrill Moore. Illus. $1.50. Twayne Pubs., New York. 1951.

The Old Egyptian Medical Papyri. Logan Clendening Lectures on the History and Philosophy of Medicine, Second Series. Chauncey D. Leake. viii + 108 pp. $2.00. University of Kansas Press, Lawrence. 1952.

The Eternal Drama. Richard Rosenheim. xi + 303 pp. + xvii plates. $6.00. Philosophical Library, New York. 1952.

Little Ship Astro-Navigation. M. J. Rantzen. 160 pp. Illus. $4.75. Philosophical Library, New York. 1952.

The Pharmaceutical Curriculum. Lloyd E. Blauch and George L. Webster. xvi + 257 pp. $2.00. American Council on Education, Washington, D. C. 1952.

Antibiotics: A Survey of their Properties and Uses. (2nd ed.) xii + 290 pp. Illus. 25*s.* plus postage. Pharmaceutical Press, London. 1952.

THE
SCIENTIFIC MONTHLY

NOVEMBER 1952

The Carbon 14 Method of Age Determination*

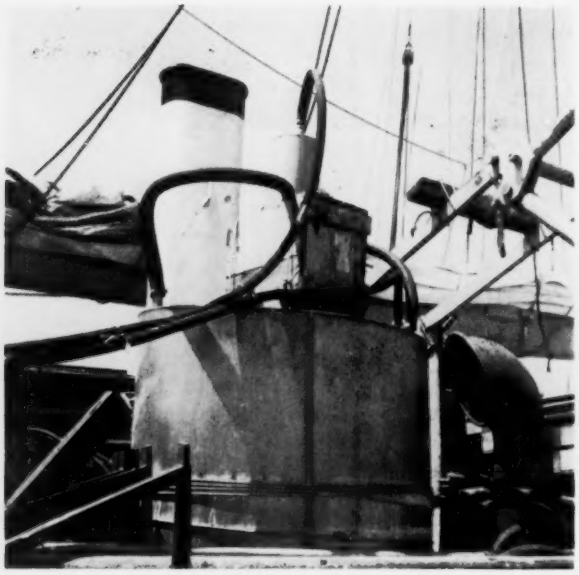
J. LAURENCE KULP

After completing the work for his Ph.D. in physical chemistry at Princeton in 1945, the author formally studied geology at Columbia as a Kemp fellow. Although his field of scientific interest became geochemistry, he was primarily occupied with quantitative geochronometry. The establishment of the Lamont Geological Observatory for research in geophysics and geochemistry made it possible for him to initiate a broad program of experimental work directed toward the time dimension in the historical sciences. At present, Dr. Kulp is associate professor in the Department of Geology and Geochemistry at the Lamont Observatory, Columbia University. In 1951, he was the recipient of the AAAS Newcomb Cleveland Prize for research which extended the range of the carbon 14 method and applied it to ocean circulation.

THE matter of time is of central importance to the sciences of geology, anthropology, and archaeology, and it is a significant factor in many others, such as meteorology and oceanography. Whether one wishes to calculate the heat flow from the ocean floor, the rate of oil formation, or to define past epochs of mountain-building or ore deposition, it is necessary to know the absolute time of specific occurrences. The only quantitative methods for measuring geologic time involve the phenomenon of radioactivity in one way or another. Up to a few years ago, methods were known, such as the decay of uranium into lead, which made it possible—in principle at least—to make absolute age determinations from the beginning of earth history to about 10,000,000 years ago. This was quite satisfactory for ancient rocks, but it did not help the glacial geologist, the student of geological processes, or the archaeologist. What was most desperately needed was a method that started in the present and that could go back through the last tens of thousands of years. Particularly important for the archaeologist and anthropologist was the criterion that the method use some element commonly found in, or associated with, artifacts. These requirements have been met by the carbon 14 method as if it had been custom-made.

The discovery of the carbon 14 method of age determination by Willard F. Libby, of the University of Chicago, was not only one of the most important scientific discoveries of the past decade but is an excellent case history of the scientific method in action. As James B. Conant so cogently pointed out in his book *On Understanding Science*, the history of science is a pulsating sort of phenomenon in which the big advances follow a new set or sets of data derived from some very considerable ad-

* Lamont Geological Observatory Contribution No. 70.



Chemical processing tank on board ship used in extracting carbon dioxide from deep-ocean water samples.

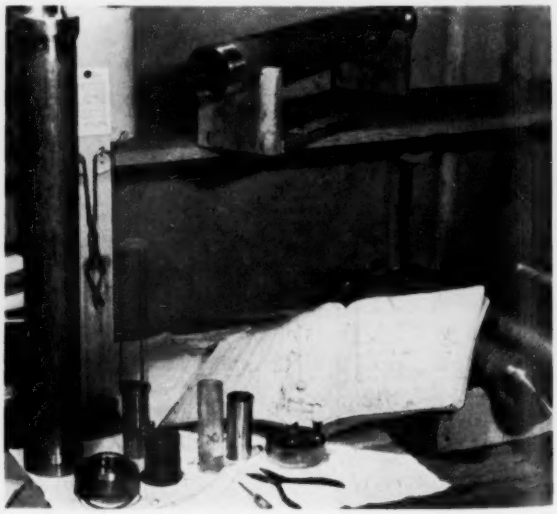
vance in technique. By the late thirties, the cosmic ray scientists had obtained some reasonably complete information on the cosmic ray flux. Also, they had begun to analyze the nuclear reactions which took place in the upper atmosphere. It was observed that secondary neutrons reacted with $_7N^{14}$ nuclei to yield $_6C^{14}$ nuclei. Libby took this isolated bit of new data and calculated the number of carbon 14 atoms produced per unit time in the upper atmosphere and the reservoir of carbon (atmosphere, biosphere, and hydrosphere) into which the carbon 14 would be diluted. Then, knowing the half-life of carbon 14, he estimated the steady state concentration of carbon 14 in the reservoir. The result of this calculation gave 12–16 disintegrations per minute per gram of carbon in the dynamic reservoir. That is, carbon dioxide of the air, surface ocean carbonate, plants that photosynthesize the atmospheric carbon dioxide, and living animals that eat plants or animals should all have the same concentration of carbon 14. This was an ingenious calculation, but it could not be tested, because apparatus of sufficient sensitivity did not exist. The first part of the scientific method had been completed; new data had been accumulated and a new theory proposed. The next step was experimental confirmation. It was fortunate that it was W. F. Libby who developed the idea, for, by virtue of long experience with radiochemistry and nuclear detection, he was uniquely equipped to solve the difficult experimental problem. After two years of the most tedious research, with the aid of E. Anderson and J. Arnold, natural radiocarbon was detected. The present value for the specific activity of contemporary carbon is, interestingly enough, 15.1 dpm/g, in amazing agreement with the value calculated several years earlier.

Since the half-life of carbon 14 is reasonably long (5568 years), and since a constant concentration is present in living things, air, and surface water, the time of removal from the carbon dioxide life cycle can be measured quantitatively if the carbon 14 concentration is determined. Thus a method was created which permits relatively precise age determination of archaeological and geological materials from the present back to several tens of thousands of years ago. (The sensitivity of present apparatus is reached after about six half-lives). The method has produced highly significant results already, and its discovery may presage the greatest single advance in historical science.

Materials

Types of natural materials that are subject to C^{14} determination include plant and animal tissue or decomposition products, air, water, ice, shells, and carbonate or carbonaceous sediments. Each type of sample presents its own problems of contamination and preparation. In the case of air or water, the carbon dioxide is removed by an absorbent in the field at the time of collection. At the laboratory, the samples therefore fall into two groups: carbonate and combustible carbon. The carbonates are reacted directly with acid, but the combustible material is always leached with concentrated hydrochloric acid prior to burning.

No matter what the nature of the sample, it should be sufficiently large so that 8 g of carbon can be recovered. This requires about 100 g of



Components of the screen-wall Geiger counter.

wood or shell, 20–40 g of charcoal, and 200–300 g of peat. Techniques have been developed for counting samples as small as 0.5 g of carbon, but considerably more effort is required for a less accurate result.

Fresh wood is the most suitable material, since cellulose does not exchange its carbon to an appreciable extent. Charcoal is generally excellent but, under certain conditions, must be checked for adsorbed organic material. Peat is satisfactory unless contaminated by more recent rootlets. Shell may be used under conditions where the possibility of exchange is low and the isotopic composition of the water in which the animal grew is known. Fresh-water aquatic plants are suspect because they may utilize carbonate carbon from the water, which may have been derived in part from old limestone. Burned bone is normally as suitable as charcoal, but, as a rule, unburned bone has lost all its organic content by subsequent bacterial action.

Technique

Carbon 14 can be measured in principle by the ion chamber, Geiger counter, proportional counter, or scintillation counter. All the published results to date have been obtained by counting elemental carbon mounted on the inside of a large-volume Geiger tube. Details of the process have been given in papers by Libby, Crane, and Kulp. The ion chamber method has been examined by Davis. It would appear that if this technique should become fully developed, it might compete with the Geiger counter method. The use of a proportional gas counter would lead to higher sensitivity, but the development of such a counter is handicapped by severe electronic requirements. The scintillation counter technique looks most promising of all.

Mounting carbon in the sample cylinder.

Placing counter into the shield. Anticoincidence and counting circuit at upper left.

The dating procedure consists of preparing a sample of pure carbon from the natural carbon-bearing material, mounting this in a special screen-wall Geiger counter, and counting it against background for several days. The key to success is the reduction of the unshielded background of the counter (about 350 cpm) to about 2 cpm by the use of elaborate shielding, anticoincidence counters, and appropriate circuitry.

The screen-wall counter is placed inside a 1-inch shield of mercury around which is a ring of anticoincidence counters. The entire assembly is inside a 12-ton iron shield, 8 inches thick. The iron removes most of the natural gammas and soft cosmic ray components and reduces the background to about 120 cpm in our laboratory. The mesons that pass through the iron shield trigger a tube of the anticoincidence ring at the same instant that they activate the sample Geiger tube in the center. The circuitry is arranged to cancel such a pulse in the sample Geiger tube. This further reduces the background to about 5 cpm. About half of this residual count is from gammas from the 12-ton iron shield. It turns out that 1 inch of mercury placed in the inside of the anticoincidence ring absorbs 85 per cent of these gammas and reduces the background to about 2 cpm. This situation makes it possible to date materials as old as 30,000 years.

Assumptions and Calibrations

There are two basic assumptions in the carbon 14 method. One is that the carbon 14 concentration in the carbon dioxide cycle is constant. The other is that the cosmic ray flux has been essentially constant—at least on a scale of centuries. In order to test the first assumption, Libby measured the

C^{14} concentration in many living trees taken from various latitudes and altitudes. He found them to be constant within the limits of experiment. Similar tests at the Lamont Observatory have confirmed the constancy in the biosphere if fresh-water aquatic plants are avoided. A major air-sampling program at widely different climatic and geographical locations and altitudes has been completed. When these samples are counted, the constancy of the carbon 14 concentration in the atmosphere may be established.

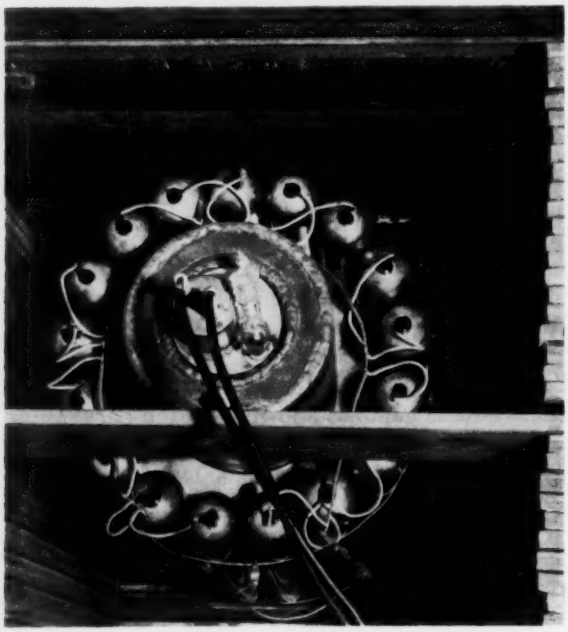
The assumption of the constancy of cosmic ray flux over the past 30,000 years is more elusive. This may be established for the past 5000 years by measuring samples whose ages are known by written history, or by some equally valid means such as tree rings. This has now been done both at Chicago and Columbia (Lamont) for numerous samples. Several representative specimens are listed in Table 1. If all the known samples are put on a plot of activity *vs.* age, it is seen that the best line through these points coincides with the theoretical decay curve for carbon 14. Since any change in the cosmic ray intensity will affect the experimental values, the coincidence of the theoretical and experimental curves proves the constancy of cosmic radiation for the last 10,000–12,000 years. Furthermore, this period overlaps the end of the last ice age, and hence the greatest climatic extremes observed on the planet. This strongly suggests that the cosmic ray flux has been constant over large periods. Another theoretical argument is that, if the cosmic ray flux is largely solar, it should vary as the total energy output. Since this variation has not exceeded a few per cent since the Cambrian period, (500,000,000 years ago), it is assumed that the cosmic ray flux has not varied either. If the cosmic rays are largely intragalactic, the time constant of any fluctuation should be long compared to the period over which the carbon 14 method can be applied. Satisfactory as these theoretical arguments may be, the skeptic, to be convinced of the reliability of dates older than 12,000 years, wants an experimental demonstration.

TABLE 1

KNOWN SAMPLES

Sample No.	Description	Known Age (Years)	Carbon 14 Age (Years)
*L-123C	Inca temple	444 ± 25	450 ± 150
L-108A	Sequoia tree ring	880 ± 15	930 ± 100
L-108B	" " "	1,377 ± 4	1,430 ± 150
*C-62	Mummy coffin, Egypt	2,280 ± 5	2,190 ± 450
C-81	Funerary ship, Sesostris tomb	3,750 ± 10	3,620 ± 180
C-12	Cypress beam, Sneferu tomb	4,575 ± 75	4,802 ± 210

* *L* = Lamont Geological Observatory, Columbia University; *C* = Institute for Nuclear Studies, University of Chicago.



Carbon 14 counter inside 12-ton iron shield, surrounded by one inch of mercury and a ring of anticoincidence cosmic ray counters.

Recently the experimental proof of the constancy of the cosmic ray flux over the past 30,000 years has been given by Kulp and Volchok. This was accomplished by dating samples of a homogeneous core both by the ionium method developed by Urry and the carbon 14 method. The ionium method depends on the fact that ionium (Th^{230}) is preferentially adsorbed on deep-sea sediments and decays with a half-life of 83,000 years, until equilibrium with uranium in the sediments is reached. This method is applicable to deep-sea sediments of a constant mineralogical type that have been continuously deposited. The method clearly does not depend on the cosmic ray flux. Six samples from three different cores, ranging from 6000 to 30,000 years in age, were analyzed for ionium and carbon 14. The ages for each sample by the independent methods agreed within the limits of experimental error. The error was sufficiently small to demonstrate the constancy of cosmic ray flux through the past 30,000 years.

Thus, with the method calibrated by written history and the two basic assumptions proved by experiment, it is ready for application to a wide variety of problems in archaeology and geology. A more complete listing of all the carbon 14 dates

so far obtained is given in papers by Libby and Kulp.

Archaeological Samples

Many specimens of archaeological interest have been submitted for carbon 14 dating. Table 2 contains a few of these dates selected to show the kinds of problems to which the method has been applied.

A Mayan lintel was discovered on which a Mayan date 9.15.10.00 was carved. According to the Goodman-Thompson correlation, this would be June 30, A.D. 741, but, according to the Spinden correlation, it would be August 30, A.D. 481; hence the proposed Mayan calendar correlations differed in absolute time by some 300 years. The carbon 14 date of 1470 ± 120 corresponds to the Spinden calendar correlation and thus fixes the Mayan culture in history.

TABLE 2

ARCHAEOLOGICAL SAMPLES

Sample No.	Description	Age (Years Before Present)
L-113	Mayan lintel with carved date	1,470 ± 120
C-576	Isaiah manuscript	1,920 ± 200
C-602	Stonehenge, England, late Neolithic	3,800 ± 275
L-134	Tunisia, early Neolithic	8,400 ± 400
C-524	Belt Cave, Iran, Mesolithic	10,560 ± 1,200
C-579	France, upper Paleolithic	13,000 ± 560
C-406	Lascaux Cave	15,500 ± 900
C-428	Oregon sandals	9,050 ± 350
L-129	Stomach contents of extinct Moa, New Zealand	1,800 ± 150
L-127	Superbison flesh and hair, Alaska	Older than 28,000
L-104A	Signal Butte I horizon, top	2,950 ± 200
L-104B	Signal Butte I horizon, bottom	3,440 ± 120

A recent discovery important to Biblical and Semitic scholars was a manuscript scroll of the Old Testament book of Isaiah. Debate ensued as to whether it was written a century or two B.C., in the second century A.D., or whether it was a medieval forgery. The carbon 14 date proved the third view to be impossible, but there was inadequate precision to decide between the other alternatives.

Specimens from England, Tunisia, Iran, and France indicate the time factor for the prehistorical cultures. The Lascaux Cave, site of the famous cave paintings of the extinct woolly mammoths, is the oldest date on a human site so far tested. The woven sandals from Oregon and several other dates from Western caves suggest that man has been in North America at least 10,000 years. Among the more exotic specimens tested were the stomach contents (now dry, fortunately) of the recently extinct Moa, a flightless New Zealand bird.

The flesh and hair of one of the widely publicized superbisons, frozen in the permafrost of northern Alaska, were measured. In both Alaska and Siberia these animals have been found in such an excellent state of preservation that dogs have eaten the flesh. The fact that this one was frozen over 28,000 years ago and preserved until now is probably the longest recorded deep freeze yet reported. The Signal Butte charcoal samples from the famous archaeological site in Nebraska show the human occupation to have extended over several centuries. The latest estimate of the age by an archaeologist (Bliss) was about 3000 years, although estimates had ranged up to 8000 years.

Geological Samples

Some selected dates of geological interest are shown in Table 3. One of the most important geological problems is the time of retreat of the last continental ice sheet. The first two samples of extinct forest now overlain by the latest drift show that the last continental glacier was still in Wisconsin 11,000 years ago. Many additional samples are making it possible to understand the absolute time of the advance and retreat of the ice during the last part of the ice age. The Mississippi delta and Bermuda samples show the worldwide change in sea level accompanying the last glacial period. The weathered surface at 273 feet corresponds to the maximum sea level lowering. Then, as the ice melted, there is a complete record of sea level rise as a function of time. It was about 80 feet lower

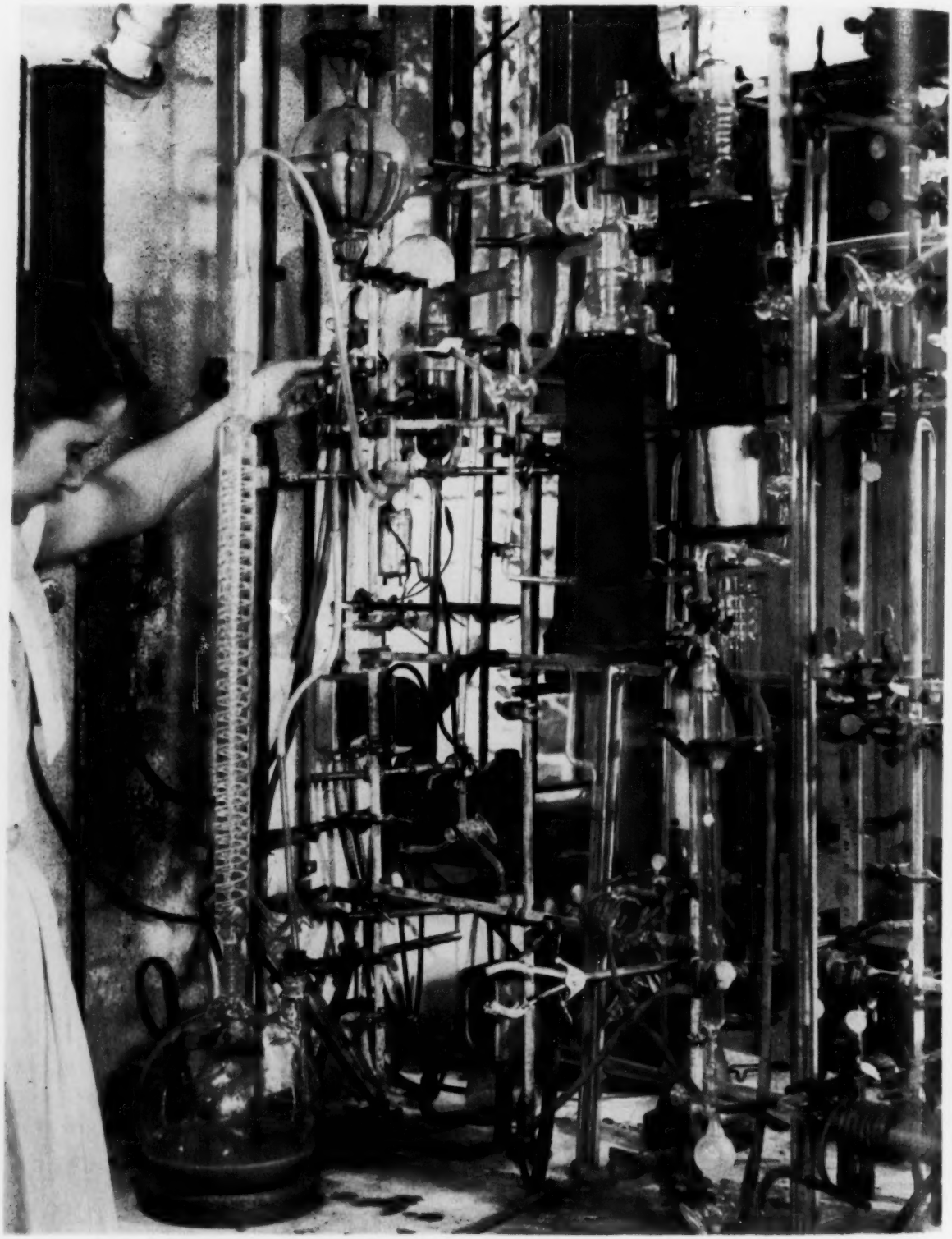
TABLE 3

GEOLOGICAL SAMPLES

Sample No.	Description	Age (Years Before Present)
C-308	Two Creeks, spruce wood	10,880 ± 740
C-366	Two Creeks, peat	11,100 ± 600
L-125I	Mississippi delta, weathered surface, 273′	Older than 30,000
L-125G	Mississippi delta, shell 73′	9,000 ± 200
L-125A	Mississippi delta, wood 25′	2,900 ± 300
L-111A	Bermuda drowned forest, 70′–90′	11,500 ± 700
L-111B	Bermuda peat	6,900 ± 150
L-141A	Florida Everglades peat	4,900 ± 200
L-114A	Southern California, 75′ (lowest) terrace	Older than 30,000
L-102A	La Soufrière, charred wood from last eruption	550 ± 150
L-101B	Eagle River, Alaska, peat	14,300 ± 600
L-150C	Rapa Island, Central South Pacific lignite	Older than 30,000

than now 11,000 years ago, 70 feet at 9000 years, 50 feet at 7000, and 25 feet at 3000.

Several samples of peat at the bottom of the peat section from different parts of the Florida



Releasing carbon dioxide from adsorbent by acidification prior to purification. Air sample taken from 30,000 feet over the Southwest.

Everglades have been dated. They all give ages around 5000 years, suggesting that just prior to this the lower peninsula of Florida was under water. It is important to note that this apparently occurred near the thermal maximum.

On the California coast, marine terraces are very well defined. It was of interest to find out if the lowest, last terrace was produced within 30,000 years. It apparently was not.

The last great eruption of La Soufrière, Island of Guadeloupe, was dated at only 550 ± 150 years ago by a piece of charred wood underneath the volcanic deposits. The Eagle River peat shows the existence of a local warm phase in Alaska about 14,000 years ago, prior to the end of the Wisconsin glaciation. Apparently several tens of thousands of years are required to form lignite from peat, as noted for the youngest lignite on Rapa Island.

A perennial problem of geochemistry and geology has been the origin of petroleum. Most theories included a long period of time—e.g., 1,000,000 years for the hydrocarbon molecule to be prepared. This was followed by migration and accumulation. It had further been frequently stated that Recent marine sediments contained no hydrocarbons. Paul V. Smith, Jr., of the Esso Laboratories, making use of modern organic techniques in brilliant fashion, began a new search for such hydrocarbons and discovered them in appreciable quantities. Not only did he find enough hydrocarbon to account for known petroleum reserves, but the spectrum of compounds was similar to crude oil. The problem remained as to whether these hydrocarbons had diffused up from oil-bearing horizons below or whether they really form *now*. Although the extremely small quantities of hydrocarbon available required the development of special techniques, it was possible by carbon 14 determinations to demonstrate that the hydrocarbons were geologically Recent, and thus the problem of the origin of oil becomes the problem of accumulation only.

Deep-Ocean Circulation

One of the basic problems in oceanography is the rate of turnover of the ocean. It is too slow to measure directly, and speculations on this rate have differed by orders of magnitude. The discovery of carbon 14 in nature made an attack on this problem possible.

Although atmospheric carbon dioxide is in equilibrium with the carbonate in surface ocean water, the submergence of such water cuts it off from its supply of carbon 14 as effectively as does death in the case of a plant or animal. Since ocean water sinks in the polar regions and moves along the bottom toward the equator, the rate and direction of movement can be measured by determining the time since a unit of water left the polar surface.

The techniques required for such measurements are quite elaborate. With the cooperation of Maurice Ewing and his associates, who have solved numerous "impossible" problems of scientific measurement on, in, and under the ocean, adequate equipment was developed and employed. The amount of carbon in ocean water is so small, compared to the quantity required for measurement, that at least 200 gallons of water are needed for each sample. An open tank was devised which could be let down in the ocean to a depth of 3–4 miles, and at the appropriate time large doors are made to close, sealing in the 200 gallons of water from that depth and location. The sample is then brought to the deck of the ship, acidified, and the carbon removed from the water quantitatively by passing through pure nitrogen gas, which carries the carbon dioxide to a suitable absorbent. The carbon that was in the 200-gallon sample is now on the surface of an absorbent in a 1-pound jar. This is returned to the laboratory for chemical processing and counting.

The carbon 14 measurements of several water samples taken from the ocean floor at about the latitude of Newfoundland on either side of the Mid-Atlantic Ridge are shown in Table 4. The data suggest that it takes about 1500 years for the water to reach this latitude from the Arctic. Thus the time for the turnover of the oceans must be thought of in terms of several thousand years. Previous estimates based on few quantitative data ranged from tens to thousands of years, but it is only with the development of radiocarbon dating that the rate of circulation may be accurately measured.

TABLE 4

DEEP-OCEAN WATER

Location	Depth	Cpm	Age
54°35′N 41°W	Surface	(1) 6.82 ± 0.09 (2) 6.74 ± 0.07 Av. 6.77 ± 0.06	Recent
	Average, modern shells	6.72 ± 0.10	
58°19′N 32°56.8′W	1829 m	5.38 ± 0.07 5.60 ± 0.11 Av. 5.45 ± 0.06	1,600 ± 130
53°52.6′N 21°06′W	2743 m	5.31 ± 0.12 5.36 ± 0.12 Av. 5.34 ± 0.10	1,750 ± 150

The knowledge of this rate has many other interesting applications besides physical, chemical, and biological oceanography. Geophysics and meteorology are also affected. One of the fundamental questions in geology has been whether granite, which is assumed to be the essential structural component under the continents, also occurs in the crust under the oceans. Major problems in early earth history could be settled if this fact could be ascertained. The seismic work of Ewing and coworkers in recent years suggests strongly that granite is absent under the ocean floor; therefore the continents (one fifth of the land area) must be abnormal, considering the earth as a whole.

The determination of the rate of deep-ocean circulation adds a strong independent argument to the case for the absence of granite under the ocean floor. Since the rate of circulation of the deep-ocean water depends on the heat flow from the crustal rocks under the ocean, and since this heat flow is very different from granite and basaltic rocks, the measurement of the rate of circulation will define which rock type is present. Apparently, the rate is so slow that the rock under the ocean floor cannot be granite.

Knowledge of the rate of the deep-water circulation is important in the problem of long-range weather forecasting. If the rate of turnover of the oceans is known, and the temperature of the water at various positions fixed, the mean annual temperature may be predicted, since the average temperature of the ocean water is a major factor in determining the surface temperature of the planet.

In a more immediately practical vein, such information might be useful in predicting movement of contaminated water in an underwater atomic explosion. In order to acquire the many measurements required to elucidate these fascinating problems, sampling gear is being operated on vessels of the U. S. Navy Hydrographic Office and the Woods Hole Oceanographic Institution.

Some Problems and Future Possibilities

Several interesting side problems have developed in the course of this work. It appears, for example, that along coastlines with deep troughs offshore, such as along Japan, Peru, the Aleutian arc, and, to a less extent, California, upwelling of the deep "old" water sufficiently reduces the carbon 14 concentration of the carbonate so that shells of living animals show apparent ages of 1000 to 3000 years. This effect is not observed on mid-ocean island beaches or along a coast with a broad continental shelf, such as the Atlantic.

It also appears that certain types of lake plants may utilize carbonate carbon derived in part from rock erosion; hence, anomalous carbon 14 concentrations appear. Fortunately, these are a negligible proportion of the plant kingdom. No difficulties have been encountered from wood, charcoal, or the other more common materials used for dating.

Great care must be exercised in order to avoid even slight contamination in the laboratory processing. Chemicals must be purchased in large lots and

Taking a ground-level sample of atmospheric carbon dioxide.

separately tested. The dry carbon must not be exposed to the air for any appreciable length of time. It is noteworthy that any laboratory error will only tend to make the age appear too young.

The future possibilities for carbon 14 dating are at least as exciting as the past results have been. For example, liquid scintillation counting offers a factor of 10 to 100 in either precision or sensitivity. It seems perfectly feasible, if this technique is developed, to measure back to 100,000 years ago or to an accuracy of ± 5 years 2000 years ago. This would not only vastly extend the application to geological processes and archaeological detail but would probably permit detailed studies of natural isotopic fractionation processes with carbon. To geochemists the fine structure that would be revealed would probably present the most entrancing problems of all.

Thus carbon 14 dating faces a bright future if AEC scientists do not get too many home-grown

carbon 14 atoms into the cycle before the low-level geochemists have a chance to examine it. On the other hand, the addition of a measurable quantity of carbon 14 would permit some tracer experiments on a global scale.

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BOLD SILHOUETTES AND FOOTSTEPS

The woodland canvas
Brashly stroked with fingerpaints
But yesterday
Is now wiped clean.

The boulders,
Those giant pillows of the earth,
Seem more unlaundered than before;
Their cases, lichen-laced,
A gray-green brown.

The vacuumed trees,
Knee-deep in litter,
Stand stark and charcoal-stroked.

The pond,
Framed by their tresses,
Is but a smoky patch of shrunken sky
Where wisps of clouds vie
In the rippled footsteps of the wind.

JOSEPH HIRSH

New York

Out of Alchemy into Chemistry*

WILLIAMS HAYNES

Mr. Haynes is the well-known pioneering chemical economist and writer on chemical subjects. Currently serving as a chemical consultant to an old investment house and a New York bank, he is finishing the final volume of his history of the chemical industry. The latest of his popularizations of chemistry, Cellulose—the Chemical that Grows, *will be published in March by Doubleday. As relaxation from the arduous work of interpreting chemistry for the layman, he raises and shows smooth-haired fox terriers and dabbles in colored photography.*

AMONG the fruits of the intellectual revolutions of the seventeenth and eighteenth centuries, the scientific spirit of inquiry into the laws of nature blossomed late and matured slowly. It was well into the 1800s before the pioneering discoveries made in chemistry during the previous 200 years began to be applied to the workaday problems of making chemicals. This deliberate development was inevitable. At every stage it had to await the happy conjunction of favorable economic conditions and applicable technical knowledge.

The birth of industry in North America was also slow and painful. It was retarded, time after time, by the jealousy of British manufacturers. Thanks to the mercantilist ideas which economists then preached and politicians practiced, this natural rivalry was deliberately twisted to the advantage of the Mother Country. Nevertheless, with all these handicaps, colonial industry outran colonial science. This was also true in Europe. Between 1600 and 1800 chemistry was comparatively strong in its practical applications and distinctly weak in its scientific discoveries.

Both had their roots in alchemy. The craftsmen of that day who used chemical processes—the bleachers and dyers, the tanners, the makers of paint and varnish, the brewers, vintners, and distillers, the workers in metals and alloys, the glassmakers—inherited all the techniques and skills accumulated by the alchemists. They made good use of them. On the other hand, the earliest chemists had to break some bad habits of their alchemical predecessors, patterns of thought and action that choked the true scientific spirit, making it secretive and inarticulate.

At the beginning, alchemy in both China and Egypt was closely allied to religion. The early alchemists were philosophers of a sort, mystical moralists. In its later stages, at the time when the true chemists repudiated its theories and practices, alchemy had become a cult, not mystical in its inspiration, but mysterious in its practices, with deliberate intent to deceive. Inspired by get-rich-quick ideas, its chief practitioners had become charlatans. They failed to transmute baser metals into gold, but they did not hesitate to transfer gold to their own pockets by any rascality.

Breaking with these besmirched ideals—and we may be sure that it was not always easy to escape their taint—the early chemists swung to the opposite extreme. They became ivory-tower scientists. They unfeignedly worshiped pure science. Their work was unadulterated research without expectation of material reward. They prided themselves upon being strict amateurs, seeking the explanation of chemical phenomena with no thought that their discoveries might be useful to mankind. The aloofness of the first chemists delayed the useful application of their discoveries, but it was probably necessary. Not until chemistry was clearly recognized as something quite different and distinct from alchemy did Lavoisier manage a gunpowder factory for the French government, Sir Humphry Davy devise the miners' safety lamp, Michael Faraday invent electrical appliances that he recognized would someday be taxed.

The practical men who made chemicals and worked with chemical processes in other industries used the tools and skills of the alchemists with no such qualms. Whatever their motives, the alchemists, in manipulating all sorts of materials for a thousand years, had built up quite a stock of chemical apparatus, accumulated a good working knowledge of a number of chemical processes, and acquired surprisingly skillful laboratory techniques. They possessed many familiar laboratory utensils, beakers, test tubes, flasks of various shapes and sizes made of metal and alloy, pottery, chinaware, and glass. They had invented both the sand and the water bath, the twisted worm still, the crucible.

* Abstracted by the author from his forthcoming "American Chemical Industry: A History in 6 Volumes," copyright by D. Van Nostrand Co., Inc.

They used all this laboratory equipment effectively. They understood percolation and filtration, distillation, sublimation, and evaporation, and they carried out these processes with an efficiency amazing when we consider their lack of scientific knowledge and their limited tools.

The tardy development of chemistry was due to two causes. First, although the early chemists were able to manipulate materials with considerable dexterity, they were unable even to approximate any degree of accuracy. Second, in groping to apprehend the true nature of elementary substances and then to explain the character of chemical reactions, they twice got off to false starts that led them up blind alleys.

Among all the apparatus the chemist inherited, accurate instruments for measurement were conspicuously absent. Physical volume could be determined simply and compared exactly. But even here there were no fixed, recognized standards. The alchemist's inability to measure mass accurately was a heavy handicap.† But when chemistry began to emerge from alchemy during the late sixteenth century, the best balances were sensitive only to one grain. It was about 1650 before half a grain could be determined precisely, and 1825 before steel-knife edges and agate bearings made a hundredth of a grain accurately determinable.‡

The measurement of heat became industrially important in England during the eighteenth century, with the practical application of the steam engine and the rapid expansion of the distilling industry, notably of gin and rum. In fact, more accurate thermometers and the development of theories of the latent heat of freezing and evaporation, to which Fahrenheit (1686–1736) and Black (1728–1799), respectively, made major contributions, represent early alliances of practical craft experience and scientific research which during the nineteenth century were to be so fruitful of results.

To the early chemists the scrupulous measurement of heat was not so important, but their inability to handle delicate reactions and processes was a grave handicap. Wood and charcoal fires, even when equipped with bellows and confined in ingenious grates, were poor substitutes for the gas burner and the electric furnace, and without heat-proof glass and tough chemical porcelain, the chemist was indeed hard put to it to employ heat efficiently in his laboratory reactions.

† The Egyptians, 1370 B.C., had balances sensitive to two grains, and the Romans about A.D. 350 could measure one half grain.

‡ Not before 1930 did the modern standard reference balance achieve .0001 grain.

The most serious drawback of all, however, was the impurity of the reagents with which the early chemists were compelled to work. The foundations of chemistry were only to be laid bare by the study of reactions, and when the reacting compounds contained unsuspected impurities the results were sure to be dubious, if not misleading. Even identical experiments performed scrupulously by the same man frequently ended in flat contradictions. Today, we have ready command of literally thousands of chemicals pure to the third and fourth decimal point, but the early chemist was accustomed to prepare his own reagents. He started with raw materials that reeked with impurities and at the end lacked means of precise, qualitative determinations. The wonder is not that the advance of chemistry was slow and painful, but that the early experimenters, with their uncertain materials and clumsy apparatus, were able to establish conclusively the first principles of the science.

Recognition of the true character of chemical reactions was blurred and delayed by preconceived ideas as to the nature of matter. These erroneous conceptions had amazing vitality, nourished by classical authority. They were embroidered with a numerical symbolism that appeared to fit together into a logical system that seemed to make sense.

Air and water, obviously fundamental materials of our environment, were naturally assumed to be elementary substances. Even today anyone ignorant of chemistry often thinks of these compounds as elements. To air and water, Empedocles about 450 B.C. added earth and fire, the four great basic elements, which he taught to Plato, who passed the idea on to Aristotle, who elaborated the four elements into a cosmic formula. No one seriously questioned these ideas until the sixteenth century.

The four elements of the Greek philosophers became the four elemental substances of alchemists: sulfur, mercury, salt, and air. But this fourfold division of the universe did not stop there. The cosmos was divided into the animal, the vegetable, the mineral, and the spiritual kingdoms. Medicine adopted this quarterly classification both for physiology and psychology, neatly joining and balancing the organs and the temperaments:

Blood (liver)	Sanguine
Black bile (spleen)	Melancholic
Phlegm (lungs)	Phlegmatic
Yellow bile (gall bladder)	Choleric

The mathematicians early described the four regular polyhedrons: the cube, the tetrahedron, the octahedron, the icosahedron. When the fifth, the dodecahedron, was discovered, they devised the ingenious explanation that this represented the en-

tire universe, thus cementing together this neat quartering of the world and all its works.

A speculative mind too easily conceived significant interrelationships between the four sectors. Fire, sulfur, blood, the sanguine temperament, and the animal kingdom were linked together, not only in some mystical manner, but as a very practical actuality. Thus, too, water, mercury, black bile, the melancholic temperament, and the vegetable kingdom became a definite group; then earth, salt, phlegm, the phlegmatic temperament, and the mineral kingdom; and finally air, yellow bile, the choleric temperament, and the spiritual kingdom. Just to seal the evidence, there were the familiar fourfold divisions of time and space, the four seasons of the year and the four cardinal points of the compass.§ Fantastic as such a conception of the cosmos seems to us today, it contained a number of apt, obvious analogies that charmed the scholastic mind and it provided what appeared to be a reasonable explanation of the universe.

In overthrowing this sophistical cosmos, the element fire became the crucial point, and chemistry was not firmly established as a science until the true character of combustion was understood. The alchemists must have promptly discovered that however elemental earth may be in our environment, soil is obviously not an elemental substance, but one that varies almost infinitely in composition. The true character of air, water, and fire was not easily demonstrated, and so, during the fifteenth century, without entirely discarding the classical four elements, the alchemists adopted a new concept, the three principles: mercury, the spirit; sulfur, the soul; and salt, the body—the essences, respectively, of fluidity, combustibility, and rigidity. It was a philosophy of chemistry that offered ostensible explanations for many superficial chemical phenomena. Nevertheless, it led straight to entirely erroneous explanations of chemical reactions which, unfortunately, were deceptively credible.

Since Paracelsus (1493–1541) alchemists had turned their attention increasingly to medicine, from the elixir of youth and the philosopher's stone to materia medica and pharmacology. Out of these preoccupations the idea that the bodily functions are essentially chemical arose naturally, and a theory was proposed for the chemical treatment of disorders of these functions.

Thanks to the prevalent belief that mercury, sulfur, and salt represented the fundamental qualities of fluidity, combustibility and rigidity, illness was thought to result from an imbalance of these elements. A surplus of mercury in the body induced rheumatism and melancholia; a deficiency of the same element resulted in gout. In like manner, a fever indicated that too much sulfur had accumulated in the body. Thus every possible combination of excess and deficiency of the three essential elements was elaborated for the diagnosis of all the ills of human flesh, and a system of therapeutics was devised for their treatment. Alchemists, physicians, and apothecaries collaborated. It is often difficult to determine to which of these professions many of the practitioners of the fifteenth to the seventeenth century belonged. The result was that alchemy evolved into a misguided, highly dangerous iatrochemistry, which, however, in good time developed into the chemistry that is the guide and counselor of both physiology and medicine.

Old apothecary shop, the gift of E. R. Squibb & Sons, on permanent exhibition at the Smithsonian Institution. Fixtures in the pharmacy and furniture in the study are from the Muenster Apotheke, Frieburg, and are all from the eighteenth century. Containers date from the fifteenth to the late eighteenth century. Ceiling lighting fixtures and the fireplace are reproductions. (Photos by courtesy of the Smithsonian Institution.)

Inimical as it was to its patients, medical alchemy was a long step forward. Its objectives became tangible. Its results could be measured by practical yardsticks. Eventually it set aside its mask of secrecy and shed its cloak of mystery. The center of its interest gravitated from mystical theories to scientific facts and, by recording more precisely a vast amount of experimentation, it began accumulating a store of definite knowledge that became the foundation of modern chemistry.

The practical accomplishments of this prechemical age were rather notable. The rudiments of qualitative analysis were mastered. The difference between acids and alkalies was recognized, and the three great mineral acids—sulfuric, nitric, hydrochloric—were not only identified, but prepared. Salts were deliberately procured by combining acids with a base. The ground was thus cleared for the manufacture of those simpler inorganic chemicals for which the demand arose after the Industrial Revolution.

Chemical theory limped far behind these practical accomplishments. Water and air were considered elements, in the Aristotelian sense, until after the American colonies had won their independence. It was 1774 before the Englishman Joseph Priestley

§ Quite recently navigation of the airplane and submarine has added up and down to the north, south, east, and west of the compass, a concept early Chinese thinkers had embraced.

and the Swede Carl Wilhelm Scheele‖ discovered oxygen; 1784 before Henry Cavendish¶ furnished irrefutable proof that water is composed of two gases, oxygen and hydrogen; and 1808 before John Dalton** formally presented his atomic theory. These dates emphasize the exceedingly rudimentary state of chemical knowledge 150 years ago.

Not earth, air, or water, but fire, was to prove the passkey to chemical knowledge. It was the study of heat and gases, both physical concepts, that led to an understanding of the chemical nature of combustion, an epochal chemical discovery.

The current belief in principles was easily translated into a new (and false) theory of combustion and oxidation. This assumed that a metallic element is composed of an earthy material plus the essence or principle of combustibility—that is, in the language of the times, of a calx plus phlogiston. On heating the metal, the phlogiston is driven off and the calx which remains is a new and different material.

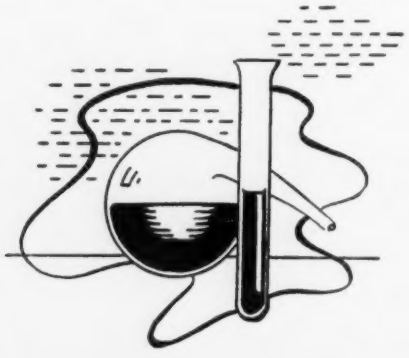
When it was noted that the calxes (oxides) of lead and tin are heavier than the original metals, this paradoxical increase of weight and loss of substance were explained by the withdrawal of levity. Comparing the calx to a corpse, it was believed that its increased weight resulted from the loss of the soul, or the living essence. This was supposed to account for the added weight of a dead body.

This phlogiston theory, according to which all combustible substances possess one component in common that escapes in the act of burning, was a conscientious attempt to form a comprehensive theory of chemical reactions. As the forerunner of all modern chemical hypotheses, it served the purpose of demonstrating the utility of such theories and the dangers of adopting them without supporting experimental proof. But the phlogiston theory, by channeling chemical thinking into a false groove, delayed the establishment of the science upon a sound basis. The very proofs that finally overthrew it, the brilliant experiments of Lavoisier, which revealed the chemistry of oxidation and reduction, were a splendid practical demonstration of the aims and methods of research. General acceptance of Lavoisier's explanation of combustion with the publication of his great textbook *La Traité Elémentaire de Chimie* in 1789 marks the birth of modern chemistry.

‖ Priestley (1733–1804) is given priority to the discovery of "dephlogisticated air," or oxygen, as Lavoisier named it, through the initial publication of his *Experiments & Observations on Different Kinds of Air* in 1774. Nevertheless, the poor apothecary Scheele (1742–86) isolated this gas two years earlier, but his *Chemical Treatise on Air and Fire* did not see print before 1777. A practical pharmacist and an avid experimenter, Scheele is credited with numerous chemical discoveries, among them the isolation of tartaric, lactic, citric, and other vegetable acids, glycerin, chlorine, arsenic, prussic acid, etc. Trained for the ministry, Priestley taught languages at Warrington Academy and began his chemical experiments at Leeds, where he was chaplain for six years. In 1780 he accepted a ministry at Birmingham, but his unorthodox religious and political views eventually drove him out to London and in 1795 to the New World and Northumberland, Pa. Besides O_2, Priestley discovered NO_2, N_2O, NH_3, HCl, SO_2, and SiF_2. To the last, he rejected the universally accepted new theory of combustion.

¶ This paper appeared in *Philosophical Transactions,* and next year the equally famous one on HNO_3. Cavendish (1731–1810) was of noble birth and extremely wealthy; he attended St. Peter's College, but aside from his scientific work—and he was a "magnificent experimenter"—little is known about him. His first published researches (1766) were chemical, but he had a marked bent toward mathematical and physical (electrical) investigation.

** This year the first volume of his *New System of Chemical Philosophy* appeared, although Dalton (1766–1844) lectured on his atomic theory at the Royal Institute. In 1803, Dalton, a Quaker of humble birth and self-taught, gave up teaching school for private tutoring and lecturing in mathematics and natural philosophy in order to devote more time to chemistry. His *Observations on Meteorology,* published in 1793, led him to his doctrine of particles.



Heredity and Population Betterment*

LEE R. DICE

Lee R. Dice received his Ph.D. in zoology from the University of California in 1915. After teaching at Kansas State Agricultural College, the University of Montana, and the University of Illinois, he went in 1919 to the University of Michigan, where he has been ever since. He serves as director of the Institute of Human Biology and professor of zoology. He is the author of numerous research papers and of three books: Biotic Provinces of North America, Natural Communities, *and (with P. M. Blossom)* Studies of Mammalian Ecology in Southwestern North America. *Currently Dr. Dice is president of the American Ecological Society. He is past president of the Nature Conservancy, the Society of Systematic Zoology, the Michigan Academy of Science, Arts and Letters, and the American Society of Human Genetics. Of recent years he has devoted an increasing amount of his attention to the biology of man.*

EVERY teacher is aware that children vary in ability, in temperament, and in social cooperation, as well as in their physical features. Part of this variability is due to differences in training and past experiences, but at least part must be due to differences in heredity. In setting up any educational program, therefore, due attention should be given to the possible limitations imposed by the heredity of the students. No such program is likely to achieve complete success if it is applied rigidly to individuals who differ widely in their hereditary abilities. Likewise, the social relations among the individuals who compose any society are undoubtedly affected to some degree by their heredity.

Each child receives on the average half of his hereditary factors from his father and half from his mother. Which particular factors are received from the father or from the mother seems to be entirely a matter of chance. Each child, unless he be an identical twin, consequently receives from his parents a different combination of hereditary factors than his brothers or sisters. It is for this reason that brothers and sisters often differ strikingly from one another in certain traits. Nevertheless, brothers or sisters in general resemble one another more closely than cousins or nonrelatives.

The hereditary constitution with which each individual is endowed at conception interacts with the environment to produce the mature organism. No hereditary factor operates independently, but only in relation to the whole hereditary complex and under the limitations imposed by the physiological and physical environment. In the past much nonsense has been written in an attempt to assess the relative importance of heredity and of environment in the production of the characters of each individual. It is evident, however, that no hereditary factor can exist apart from its environment, any more than any individual organism can be separated from its environment and still remain alive. Neither can any kind of environment produce a functional organism unless it begins with a living cell which contains a full set of hereditary units.

It is futile, therefore, to argue whether heredity, home training, schooling, diet, medical care, or social environment is the more important in molding the characters of each child. What we really need is more knowledge about the effects of each of these factors in relation to the others. Only when there is an optimum of heredity, of environment, and of training can the best citizens be produced.

People are sometimes confused about the difference between congenital characters and those that are inherited. A congenital character is one that is present at birth, but not all congenital characters are inherited. Many defects present at birth are produced by embryonic accidents or by infections. Congenital syphilis, for example, is due to an infection, but this infection is not inherited, even though it is transmitted directly from the mother to the child. On the other hand, many inherited characters are not present at birth, but only appear months or years later. Huntington's chorea, for in-

* Based on an address presented before an assembly of the School of Education, University of Michigan, July 1, 1952.

stance, is an inherited defect that may not appear until the individual is forty or fifty years of age, or even older. Up until the age of onset the affected individual appears to be normal; he does not exhibit the severe symptoms of nervous and mental degeneration that are characteristic of the disease.

No way has yet been discovered for treating those who carry the heredity for Huntington's chorea to prevent their developing the disease. Certain other inherited diseases, however, may be alleviated by proper treatment. Diabetes mellitus, for example, often runs in families and evidently is due at least in part to an inherited tendency. Those individuals who carry incipient diabetes, however, may not suffer seriously from the disease if they live on a diet low in carbohydrates. Furthermore, the injection of insulin assists an affected person in compensating for the failure of his pancreas to secrete this hormone, although he is not thereby cured of the disease and must continue during his whole life to take insulin at frequent intervals. His heredity is not affected by the treatment, and he has exactly the same likelihood as before of transmitting the tendency to diabetes to his children.

It is evident, therefore, that a person who has an unfortunate defect in his heredity is not necessarily doomed to a life of misery or to an inferior position in society. Many defects of heredity can be corrected, at least in part. In addition to diabetes, correction can be made for such defects as malocclusion of the teeth, cleft palate, and poor vision. For many defects, unfortunately, no corrective measures are yet known. Through research, however, we are learning how to alleviate many of the defects that are produced by or that are to some degree affected by hereditary factors.

A knowledge of the heredity of our children and our students will enable us to take all possible steps to correct or to compensate for their inherited deficiencies and disabilities. Special training programs may often be desirable corrective aids. A still unsolved problem revolves around the kind of training needed to bring out the best in those students who have inherited superior intelligence or special abilities of particular kinds.

It may be of interest to review some of the principles of genetics. Several of the traits that I shall use as examples are severe handicaps to the persons who bear them. All grades of hereditary handicaps occur, however, from those that are so slight as to be almost negligible to those that incapacitate the individual for any useful place in society.

First, let us consider Huntington's chorea, a

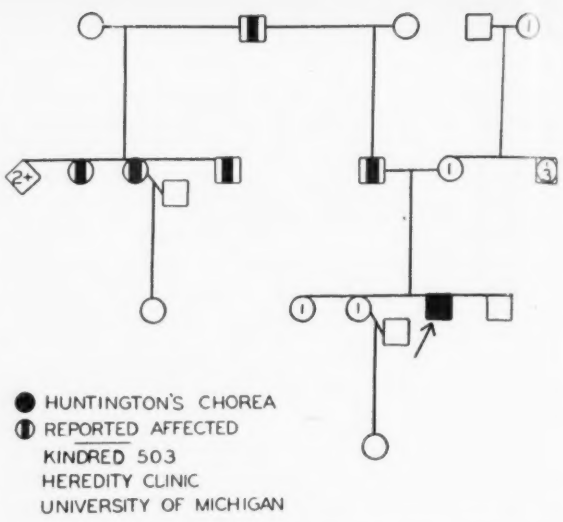


FIG. 1. A pedigree of Huntington's chorea, illustrating a dominant type of heredity. Each child from a mating between an affected and a normal individual has one chance in two of inheriting the defect. The trait may not appear until middle age or later.

dominant character (Fig. 1). It never skips a generation. Every person who exhibits a dominant character must have had an affected parent, except in those rare cases where the character has suddenly arisen as a mutation. Each child of an affected person, in the type of mating that usually occurs, has one chance in two of inheriting the disorder. Owing to the late age of onset of Huntington's chorea, unfortunately, no individual who has an affected parent can be sure that he has escaped the dreaded heredity until he has reached the age of fifty years or more without developing the preliminary symptoms. Imagine the anxiety to which every member of such a family is constantly subject! An even worse result of the late onset of this disease is that an affected individual may already have produced a family before he becomes aware that he is a carrier and that consequently he is almost certain to transmit the malady to some of his children.

Another example of a dominant character in man is retinoblastoma. This is a malignant cancer that begins in the retina of one or both eyes and spreads rapidly to the brain, causing death. It usually affects very young children, often before the age of one year. If the whole affected eye is promptly removed or other adequate treatment given, the individual may survive and may ultimately produce children, each of whom has one chance in two of inheriting the defect. Because of the high mortality of affected individuals, there is a high rate of natural selection against the char-

acter, and most cases are the result of mutation. Figure 2 shows the pedigree of a pair of identical twin girls, both of whom developed retinoblastoma in both eyes and both of whom died from the cancers. The parents were completely normal. It seems almost certain, consequently, that this was a case of mutation.

Gout is an example of a dominant character the expression of which is affected by the environment. It is well known that gout runs in families and that bankers are more likely to suffer from the disease than day laborers. The painful symptoms of the disease are caused by deposits of uric acid crystals in the joints and at other places in the tissues of the body. What is really inherited is hyperuricemia, a high level of uric acid in the blood. Not all the persons who have a higher than usual amount of uric acid in the blood, however, ever develop gout (Smyth, Cotterman, and Freyberg, 1948). On a diet rich in uric acid–forming substances, the affected individual will probably develop gout, but on a less rich diet he may escape. In any case he will seldom develop gout until the age of eighteen years or more. Males are more likely to be affected than females. Those individuals who have a high level of uric acid in the blood can be identified and can be warned (1) that they are in some danger of developing gout, and (2) that their offspring will have a certain chance of inheriting the same tendency.

Let us next consider a recessive character, amaurotic idiocy, which is sometimes called Tay-Sachs disease (Fig. 3). The affected child may appear normal at birth. Soon, however, symptoms of severe mental degeneration, paralysis, and blindness appear. The disease is always fatal. Both parents must be carriers of the disease—although both may appear to be completely normal—to produce a child who exhibits such a recessive defect. From a mating between two carrier-, but normal-appearing, parents each child has one chance in four of exhibiting the defect. As is true of recessive characters in general, amaurotic idiocy is often a sequence of cousin marriage, although cousin marriage is not in itself damaging to heredity. The mating of relatives is dangerous only when the family heredity contains one or more harmful recessives.

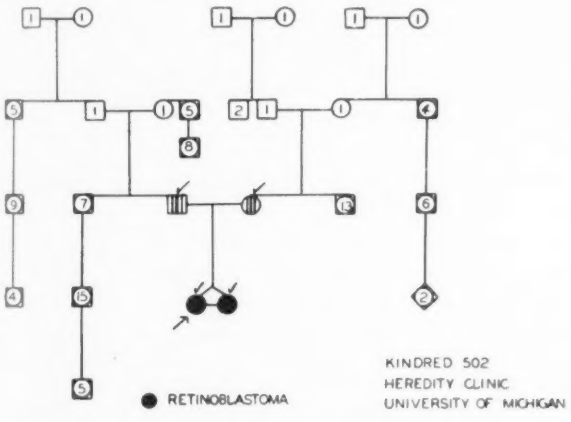


FIG. 2. A pedigree of retinoblastoma in which two identical twin girls were both affected. Their parents and all other known members of the family were normal, and it is consequently inferred that this was a case of mutation.

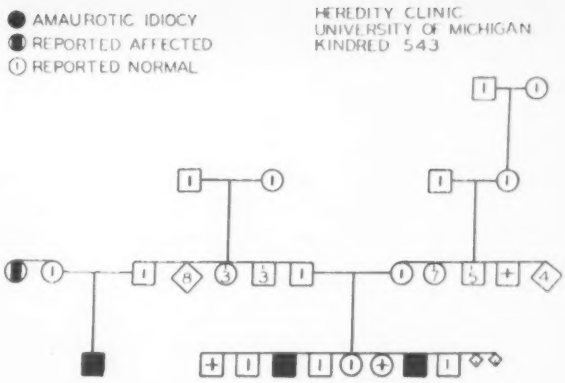


FIG. 3. A pedigree of amaurotic idiocy, which is recessive in heredity. Each child of normal-appearing parents, both of whom are carriers, has one chance in four of exhibiting the trait.

In addition to dominant and recessive types of heredity, and a number of other kinds, there is the type spoken of as sex-linked. In the pedigree of hemophilia shown in Figure 4 it is evident that only males are affected. In a sex-linked character such as this, a male can receive the defective gene only from a carrier mother and never from the father. Hemophilia is such a serious disease that the affected males nearly always bleed to death before maturity.

Red-green color blindness is another sex-linked recessive character. Color blindness is ordinarily not a serious defect, but it is of concern wherever color is employed in teaching or in industry. About 8 per cent of the males in our population are color-blind. Color-blind females are rare, but they can be produced by the mating of a color-blind male with a carrier female (Fig. 5). Should a color-blind woman marry a man with normal color vision, all their sons will be color-blind and all their daughters will be carriers of the trait.

Reliable knowledge of the mode of heredity of human mental traits is available only for some of the more serious abnormalities. Huntington's chorea

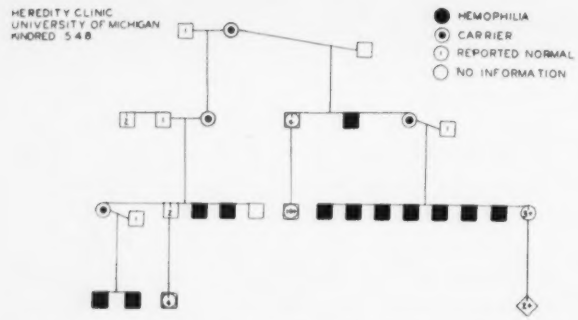


FIG. 4. A pedigree of hemophilia, a recessive sex-linked character. Each son of a carrier female has one chance in two of exhibiting the trait.

is dominant in heredity, as has already been mentioned. Amaurotic idiocy and the phenylketonuria associated with another type of idiocy are both recessive. Certain types of epilepsy and of mental disease seem also to be recessive in heredity, but with some irregularity of expression. We are still ignorant, however, of the role that heredity plays in the incidence of most types of mental defects. Nevertheless, numerous kinds of mental defects seem to "run in families." Examples of two pedigrees of mental deficiency are shown in Figures 6 and 7. The number of affected individuals in each of these families seems to be too great to be due entirely to unfavorable social environment. It is consequently probable that in some unknown way heredity is involved here.

It is suspected that certain of the mental gifts of man, such as superiority in musical ability, mathematics, or mechanical facility are in part inherited, but the evidence at hand is inconclusive. Superior ability in any type of behavior is probably the result of the favorable combination of a number of hereditary factors in an individual who happens to live in an environment suitable for the expression of the trait concerned. Conversely, it may be assumed that the absence of a particular special ability may result from the absence of the necessary heredity, from an environment that is unfavorable for the expression of the trait, or from a combination of these factors.

In other words, it is assumed that a favorable combination of heredity, environmental factors, and training is required to produce an individual of the highest ability. Inferior ability, on the other hand, may presumably be the result of poor heredity, inadequate diet, infectious disease, poor social environment, lack of proper schooling, or of certain combinations of these factors. In any particular case, such as a case of retardation in school, it may be difficult or impossible to ascertain which factor is mainly responsible.

The intelligence tests that have been developed to such a high state of excellence by the psychologists have so far not proved to be well adapted to the identification of hereditary factors, however useful they may be for other purposes. This is no criticism of such tests, but only shows that we have not yet learned how to apply intelligence tests to studies of heredity. In part, the difficulty is that the scores given by the tests are seriously affected by the education, experience, and social environment of the individual tested. In part, also, general intelligence and each special ability are probably controlled and affected by a number of hereditary factors. The tests so far devised fail to distinguish between, and to identify, the several hereditary factors involved.

Information about the heredity of temperament and of social cooperativeness is particularly difficult to obtain. In laboratory animals, it can be shown that certain traits of temperament and of behavior are in part inherited, although they can be modified by training. We presume that this is true also of man, but so far none of the tests seems to be adequate for the investigation of the heredity of temperament in man.

An individual who is a carrier for the heredity of a serious disorder may not himself exhibit the trait. This is especially true of recessive characters. Nevertheless, such carriers can sometimes be identified by careful examination. In recent years the geneticists of our Heredity Clinic and those in other institutions have been successful in discovering methods for identifying the carriers of Mediterranean anemia, sickle-cell anemia, gout, the petit mal type of epilepsy, xanthomatosis, and several other serious diseases of man. It would be a great boon to mankind if we could learn to identify

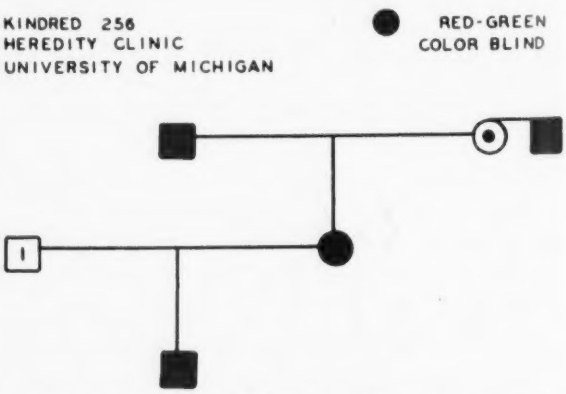


FIG. 5. A pedigree of red-green color blindness, a recessive sex-linked character. A color-blind female has been produced from the marriage of a color-blind male with a carrier female.

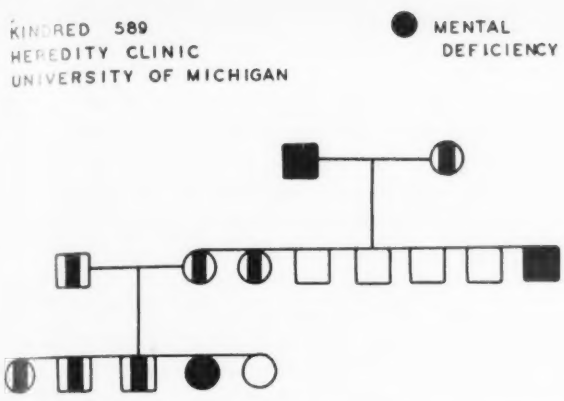


FIG. 6. A pedigree of mental deficiency. The mode of heredity is uncertain.

the carriers of all the various types of human disorders.

Much of our knowledge of the heredity of complex characters in man has been obtained by the comparison of twins. There are, as is well known, two types of twins, identical and fraternal. Identical twins are believed to originate from the division of a single fertilized ovum. Such twins are consequently identical in their heredity. They are always of the same sex, they look very much alike, talk alike, and have closely similar interests and abilities. Fraternal twins, on the contrary, may be of opposite sex and are expected to be no more similar in heredity than any other pair of brothers and sisters.

Part of the similarity between twins of the same pair is undoubtedly due to the fact that they are nearly always reared together and consequently have closely similar training and quite similar social and economic environments. The two members of a set of fraternal twins, nevertheless, even if they are of the same sex, always differ much more from one another than do the members of a set of identical twins.

It is important to note that identical twins are never exactly alike in all their characteristics. Their mothers can nearly always tell them apart by certain slight differences in their features, speech, or behavior. These differences may be considerable if one twin is infected by a serious disease or suffers an accident which the other escapes, or if the two are reared apart in different social and economic environments.

That the heredity of the world population is deteriorating has been suggested by a number of students of human biology. This deduction is based mainly on the occurrence of differential fertility among the classes in our society and among the races and subraces of the world. In most industrialized countries, the unskilled workers average more children per family than the skilled workers. Skilled workers in their turn have larger families than professional persons. Those parents who have received only a grade-school education have on the average more children than college graduates. If it were not that some parents who have themselves had only a grade-school or high-school education send some of their children to college, our colleges would in a few generations have no students at all. Those parts of the world that are backward in culture likewise are increasing in population at a higher rate than those that have highly developed cultures.

If the abilities of skilled workers compared to unskilled workers are based in any part on a difference in their heredity, or if college graduates average higher in hereditary ability than noncollege persons, then because of the differential fertility between these classes the heredity of our population must be deteriorating. Just a few generations of adverse selection of this kind against superior heredity could have most drastic consequences for our institutions, unless it is counterbalanced by other favorable factors.

That serious dangers are inherent in differential fertility cannot be doubted. The danger of catastrophe, resulting from the deterioration of the heredity of our people is, however, probably not as imminent as certain authors have assumed. Up to the present time, we have no satisfactory information about the trend of heredity in any population for those characters that are related to intelligence, temperament, or social adjustment. Actually, we know very little about the mode of heredity of any of these traits. Although good heredity is undoubtedly an important element in the production of superior intelli-

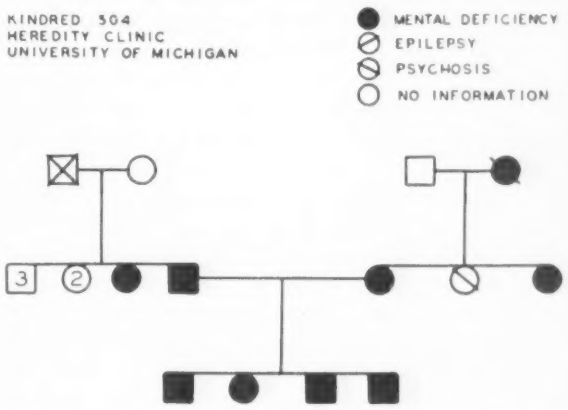


FIG. 7. A pedigree of mental deficiency and other mental defects which seems to indicate hereditary transmission of some type.

gence and of successful adjustment to social life, many factors of training and of social conditioning may be presumed also to control human behavior and to determine the position that each person comes to occupy in his society.

Superior ability is probably usually the result of a happy combination of good heredity, favorable social environment, and suitable educational facilities, as has earlier been pointed out. Often it is related to good health, which is in part dependent upon an adequate diet and on a hygienic habitat. Insofar as it is based on heredity, superior ability may be assumed always to result from the combined effects of a number of favorable genes. The lack of any one of the necessary hereditary units may prevent the individual from being superior or may make him decidedly inferior.

Those numerous genes that in proper combination produce innate superiority in mental ability must be widely dispersed in the population. Every person, no matter what his social class, may be presumed to carry at least a few of them. The failure by a superior individual to produce the number of offspring necessary for his replacement in the next generation will of course result in the loss of some of his valuable genes, but the total loss compared to the reservoir of favorable genes in the whole population may be small. The actual magnitude of the loss that results from differential fertility is completely unknown.

In addition to differential fertility, several other genetic factors may affect the heredity of populations. Among these, mutation, random loss of genes, assortative mating, and adverse selection are probably of most significance for human populations.

The mutation rates that have been estimated for human characters are all considerably higher than those in fruit flies and other simple animals. For retinoblastoma, for instance, the mutation rate in the state of Michigan has been estimated by James V. Neel and Harold F. Falls (SCIENCE, **114**, 419 [1951]) at 2.3 cases per 100,000 births. Roughly, then, each child born in Michigan has one chance in 40,000 of exhibiting a mutation at this gene locus. Mutation rates that have been estimated for other characters of man are of a similar magnitude. When we consider that man has probably 20,000 or more gene loci where mutations can occur, it is evident that mutation must be an important factor in the heredity of human populations. With such high mutation rates as occur in man, harmful mutations will rapidly accumulate in our populations unless selection is effective in eliminating them promptly.

There is a constant random loss of hereditary factors from every population through the failure of certain individuals to leave offspring, and from other causes. Should a particular gene be carried only by a single individual, for instance, the failure of this individual to produce offspring will mean the permanent loss of that gene. Which particular genes will be lost in this manner is usually a matter of chance. Valuable genes are just as likely to be lost by chance as harmful ones. A rare hereditary factor may in a small population be carried only by one or a very few individuals. Such a rare factor will be easily lost, and if once lost it can only reappear in the population by a new mutation or by interchange with some other population. The chance loss of genes must be of frequent occurrence in small populations, but in large populations it is probably negligible, except for very rare genes.

Assortative mating is the tendency for individuals to select mates who are like themselves. In general, persons seem to select mates who have physical and mental characters similar to their own, who have similar tastes, and who come from the same social and economic class.

Assortative mating should, theoretically, have a tendency to divide a population into hereditary classes or castes. In many countries assortative mating divides the people into upper and lower classes. In India the caste system is most conspicuous, but we have no satisfactory information about possible differences in heredity between the several castes. The differences in social environment among these castes is so great that it would in fact be difficult to measure the difference in heredity that may have evolved in the course of time. In most populations there is a considerable degree of intermarriage among the social classes, and the actual effects of assortative mating in our own country are as yet unknown.

Adverse selection against a hereditary factor may operate at any stage in the life cycle. There is a considerable loss of the embryos of all kinds of mammals before birth, some of which is due to accidents, to poor health of the mother, or to other environmental causes. A part of this prenatal loss, however, is known to be due to certain embryos having received unfavorable combinations of heredity that do not permit them to develop properly. Certain embryos also may carry heredity that is incompatible with that of the mother. A rhesus-positive embryo carried by a rhesus-negative mother, for example, is in some danger of developing erythroblastosis fetalis.

Some postnatal adverse selection also occurs in man. Many children are born with serious abnor-

malities that are due to hereditary deficiencies. Some of these die in childhood. Many who are born with minor defects can be kept alive by medical skill, but some of these, because of their handicaps, do not marry, and consequently their defective heredity is ultimately eliminated.

Little reliable information is available about the amount of defective heredity removed from each human generation by adverse selection acting in embryonic life or later. This factor must, nevertheless, be effective in removing a considerable number of genes from human populations. At least those more extreme hereditary modifications that render the individual unable to survive are eliminated. The most efficient service of adverse selection is probably through its removal of a large proportion of the more seriously harmful mutations that occur in every generation. Whether, in spite of this natural adverse selection, harmful mutations are accumulating in our populations is unknown.

In spite of the admitted potential dangers to every human society through the possible deterioration of its store of heredity, no catastrophic decline in the ability of our population seems likely to occur immediately. There are, in fact, a few hopeful indications for the future. We are gradually increasing our knowledge of the role that heredity plays in the production of human traits of all kinds. Through scientific publications and through heredity clinics this knowledge is being made available to the public. In our educational programs special facilities are being provided for the training of handicapped children. There is even some indication that the birth rate of the well-to-do class in our population has increased slightly in recent years. There is consequently some hope that the differential fertility among the classes in our population may in time diminish or be reversed in direction. I have confidence that through the cooperative efforts of research scientists, physicians, educators, and other persons of good will, we shall ultimately overcome the dangers to the heredity of our modern societies.

My optimism does not end with the expectation that we shall in time be able to prevent the deterioration of the heredity of our populations. I firmly believe that through an increase in knowledge of the mode of heredity of human traits and through the extension of the system of heredity clinics, we shall in the future be able greatly to reduce the incidence of hereditary human defects and deficiencies and to increase the proportion of persons who are endowed with superior health, special mental abilities, and increased social cooperation. These resulting improvements in heredity can contribute, along with improvements in our technology, in our educational programs, and in our political and social organizations, toward the making of a better and a happier world.

WINTER SKY

While scientists still seek it—
  Some latitudeless place
That lies beyond our knowledge,
  A planet hung in space

That teases with a distance
  More measureless than "far,"
Once more we scan the winter sky
  For each familiar star.

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The Biosynthesis of Fibers

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THE bulk of most organisms, after allowing for water and inorganic substances, is made up of tissues having a fibrous texture. The importance of understanding how such fibrous materials are synthesized is therefore obvious; on the other hand, the structural complexity of natural fibers, manifest at every level of organization, emphasizes the peculiar difficulties of this problem. During the past decade the application of the electron microscope to the study of biological systems has made possible the determination of structural details of the order of 50 A–1000 A, which are likely to be of significance from the viewpoint of biosynthesis. Representatives of most common fibrous tissues have now been examined, but little attempt has been made to survey these results or to draw general conclusions.

From the X-ray examination of fibers, one broad generalization concerning their molecular structure was advanced by Meyer and Mark[1] and developed in particular by Astbury.[2] According to this hypothesis, all fibers at the molecular level consist of long molecular chains oriented parallel to the fiber axis. The resolution of the electron microscope is not yet such that direct visual confirmation of this view is possible, and therefore any conclusions drawn from microscopy should be at least compatible with the X-ray findings. Microscopy has proved most fruitful in revealing details concerning the next higher level of organization—i.e., the level of fine histology or "fine structure"[3] (Table 1). Although this type of investigation is still in its infancy, it would seem useful even at this stage to consider the possibilities of a second broad generalization concerning natural fibers. This hypothesis is that a fine fibril, usually of diameter ranging from 50 to 200 A, variously referred to as a microfibril or a protofibril, forms a fundamental building element of the fibrous structure in both protein and carbohydrate fibers. The evidence for this hypothesis in several individual cases will be discussed below. First let us consider in a theoretical way the usefulness of the concept of an elementary fibril (protofibril is perhaps the best term) in explaining some of the facts relating to fiber synthesis.

Most speculations concerning this subject have considered first the synthesis of long molecular chains and then have developed various mechanisms for orienting these chains to give the organization evident at higher levels. If, however, the protofibril occurs as a structural element of dimensions intermediate between those of a long-chain molecule and the finest fibrils visible in the light microscope, it is necessary to consider its formation and subsequent reactions as basic steps in the course of synthesis. Logically, then, three stages may be distinguished in the growth of a tissue having a fibrous texture:

a) *Primary Synthesis.* This means the formation of a high molecular weight particle which may or may not have a markedly asymmetrical form and which forms the precursor of the protofibril. The synthesis of this precursor is probably similar in principle to the biosynthesis of other high molecular weight compounds and establishes an initial similarity between the soluble high molecular weight compounds and the insoluble condensed phases of fibrous texture.

b) *Protofibril Formation or Fibrillation.* This step is the transformation of the products of the primary synthesis into the fibrous form and leads to the appearance of the protofibrils. Since the resulting fibrils are of an appropriate size (diameter 50–500 A), this step can often be studied in the electron microscope. It has also been referred to as the globular-fibrous (G-F) transformation,[3,4] usually with the implication that the globular or corpuscular precursor condenses immediately into the protofibril.

c) *Organization* and consolidation of the protofibrils into formations of still higher level of organization, which build up and become visible in the light microscope. This picture of fiber building is set out schematically in Table 1.

Our purpose is to discuss stages (*b*) and (*c*) in some detail and to point out the usefulness of these concepts in accounting for the development of the quite complicated fibrous formations actually observed at the macromolecular level.

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Fibrillation or Protofibril Formation. As mentioned above, the intracellular synthesis of the precursor particle may be supposed to take place in a manner similar to that which gives rise to other high molecular weight soluble substances. Not much is known of this primary process, and for our present purposes the formation of such molecules may be assumed, as we are concerned rather with the transformation of the soluble precursor into the condensed insoluble fiber, a step which may occur inside or outside the mother cell. When these soluble precursor compounds have been obtained in vitro, it is usually found that they do not consist of long filamentous single-chain molecules. They resemble, rather, the more familiar corpuscular proteins, and it is reasonable to assume that they also possess an elaborately ordered inner structure, as has been revealed in detail by Perutz and Kendrew in haemoglobin and myoglobin.[5] The transformation into the fibrous mode, the step here termed fibrillation, can result from very slight changes in environmental conditions and may occur with great rapidity. Broadly speaking, two type-mechanisms of fibrillation may be considered: *chain unfolding,* followed by crystallization of the long chains in parallel array (Fig. 1); and *aggregation* into strings or more complex forms without the occurrence of internal disorganization (Fig. 1). Chain unfolding has been the more popular hypothesis. It explains the fringed micelle formations postulated by X-ray workers but requires some improbable elaborations to account for the discrete character, constant diameter, and often elaborate inner structure of the protofibrils found by electron microscopy. Aggregation theories can account more plausibly for the appearance of protofibrils of constant diameter and for the apparent ease of formation and reversibility of fibrillation in some instances. They also account for the elaborate X-ray patterns reminiscent of those given by crystalline globular proteins as the elaborate structure of the original molecule is supposed to be preserved in the fibril.[6] On the whole, then, an aggregation theory of fibrillation is in better harmony with the scheme to be developed here.

TABLE 1

THE VARIOUS LEVELS OF ORGANIZATION OF A FIBROUS STRUCTURE AND THE STEPS POSTULATED IN ITS SYNTHESIS

HISTOLOGICAL LEVEL 2000 A upwards (Light microscope)		Macrofibrils, etc.
	↑ Organization of protofibrils	
FINE HISTOLOGY 50–1000 A (X-ray and electron microscope)		Protofibrils
	↑ Fibrillation	
MOLECULAR LEVEL 1–50 A (X-ray)		Precursor
	↑ Primary synthesis	

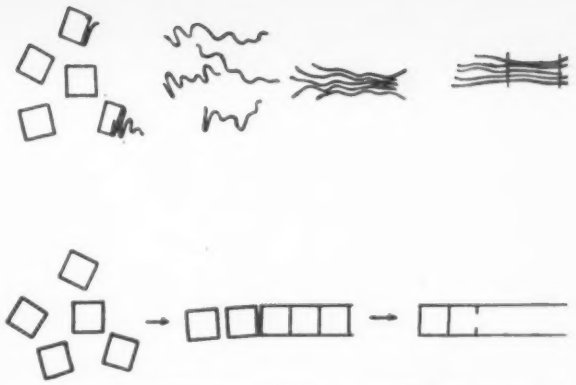

FIG. 1. Two type mechanisms of fibrillation or protofibril formation: above, molecular unfolding followed by crystallization; below, linear aggregation.

A mechanism for the formation of the long thin aggregates required by the linear aggregation theory can be suggested, although its details must await clarification. Colloidal particles are known to aggregate into strings in appropriate circumstances, and this can be accounted for in terms of colloidal forces.[7] A development of the theory of Verwey and Overbeek[8] shows that in certain conditions the potential energy barrier of a biparticle—i.e., two particles already in contact—is lowest along their ccmmon axis.[7] A third particle may therefore approach most easily in this direction and, if the barrier is surmounted, form a string of three particles. This process repeated indefinitely will lead to long strings of particles. However, in order to produce a system oriented also at the molecular level, as is required to account for the fibre-type X-ray patterns, it seems necessary further to suppose that, following the initial contact produced by the linear aggregation, specific chemical forces, at first of low energy and subsequently of a covalent character, secure the appropriate reorientation of the individual particles and the consolidation of the long fibrillar forms. This may be why in some instances it has proved impossible to reverse the process and obtain again the unmodified precursor.

The relation between the protofibrils discovered by electron microscopy and the micelles postulated

to explain the X-ray diffraction phenomena calls for comment. From X-ray data the micelles are deduced to be long, thin structures not unlike the microfibrils in size and shape.[1, 2] In some cases diameters of the two may be considered identical; usually the micelles seem to be smaller. This latter case may still mean that they are indeed the same structures and that the smaller size indicated by X-ray diffraction is due to the fact that many causes contribute to the diffusion of X-ray reflections and the deduced micellar size is therefore likely to be less than that of the actual diffracting object.

Alternatively the micelles may actually be subfibrillar—i.e., they may represent local condensations of chains within the microfibrils and thus be genuinely smaller. Natural fibers often exhibit definite X-ray diffractions at low angles indicative of the presence of regular structures of great size. This has been sometimes construed as evidence for the existence of large regularly ordered particulate forms.[6, 9]

Organization of Protofibrils. With the protofibrils as building blocks various structures on a larger scale may be elaborated, leading from the macromolecular level (fine structure) to the histological level (light microscopy), as illustrated in Table 1. When ordering influences are at a minimum, tangled and disoriented forms (brush heaps) may result; when the physicochemical conditions are appropriate, tactoids may separate and condense into spindle-shaped macrofibrils;[10] mechanical influences may develop parallel orientation of fine fibrils throughout considerable volumes; surfaces with ordered patterns (templates of macromolecular order) may induce patterns with two-dimensional regularities. Since these instances are in a sense all special cases following on the more general phenomenon of fibrillation, it is better to discuss a series of examples to illustrate the particular phenomena supposed to occur.

The Keratin Fibers. The keratins in their various forms—hair, nails, horns, skin, etc.—are all fibrous at the molecular level.[11] They have been much studied, owing to the central position these proteins have come to occupy in protein theory resulting from the work of Astbury.[12] Studies by means of the light microscope and the electron microscope combine to show that the fibrous cortical cells of hair consist of bundles of coarse fibrils (*ca.* 1 μ in diameter and called macrofibrils) which in turn consist of finer microfibrils.[13] Both cells and macrofibrils exhibit a long thin cigar shape as indicated in Figure 2. The microfibrils (diameter, 200–300 A) appear to be the primary fibrillar

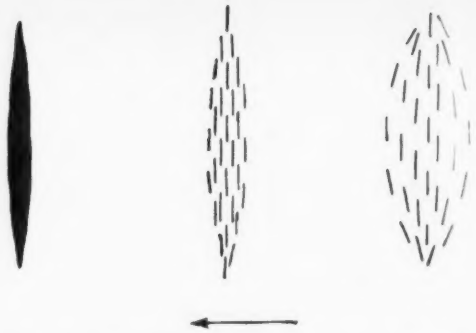

FIG. 2. Tactoid formation and condensation as steps in formation of macrofibrils.

structures, the protofibrils postulated above. The shape of the macrofibrils suggests that they are condensed tactoids produced by a process such as Bernal has described.[10, 14]

Attempts to obtain a keratin precursor in an unaltered form from the germinal layers of skin and hair have not been very successful. The molecular characteristics of the undoubtedly altered molecules in extracts of these layers in solutions of urea[15] and of dissolved wool, as well as end-group methods, suggest that a molecule of weight in the range 50–80,000 is probably of significance in this connection. We may picture the synthesis of this precursor occurring in the basal cells of the germinal layer and its subsequent transformation into protofibrils. These structures are 2000–3000 A long. The dimensions are such as to suggest that tactoids may form in a manner analogous to those of tobacco mosaic virus. The physicochemical conditions leading to long-range forces likely to cause this condensation have been much debated.[16] According to the theory of Verwey and Overbeek,[8] the ordered array of long particles occurring in localized concentrations, as in tactoids, or uniformly throughout larger volumes in appropriate circumstances, is a consequence of the shallow minimum which occurs in the potential energy curves at large distances where the London–Van der Waals' forces exceed the repulsive forces that are due to the circumscribing diffuse double layers. The long particles may "rest" in these minima at perfectly definite distances from each other; i.e., in a plane at right angles to their long axes a hexagonal arrangement will prevail. A consideration of the theory of the stability of such colloidal arrays suggests courses that may lead to an ordered aggregation in which the particles remain parallel. For instance, a gradual progressive increase in electrolyte concentration lowers the height of the potential barrier and brings the potential minimum closer in, leading finally to aggregation. The sus-

pension may separate first into localized, more concentrated, tactoids and finally condense to spindle-shaped forms similar to macrofibrils (Fig. 2). Their orientation in the hair root may be imposed by the shear caused by cell deformation. Since they form intracellularly, their length remains less than that of the cell (100 μ). The later stages of this progressive condensation and dehydration leading to the tapering macrofibrils may be followed in the light microscope.

A special reaction in the keratins which occurs subsequent to fibrillation and condensation is the hardening, or keratinization. This is supposed to be due to a cross-linking of the protein chains,[2] a reaction which proves difficult to reverse, and contributes towards the hardness and insolubility of these materials. Since these final changes occur in an orderly sequence along the length of the hair follicle, their histochemistry may be easily studied.

When special orienting influences are absent—e.g., in skin—the macrofibrils are not parallelized, but with the flattening of the cell they come to lie in one plane and are otherwise randomly disposed.

Muscles. In muscle the fibrillar elements, not being limited to the confines of a cell of the usual kind, are much longer than in hair. Coarse fibrils of a similar order of magnitude as macrofibrils are called myofibrils and are of indefinite length. In all forms of muscle, striated and smooth, the myofibrils may be resolved into fine myofilaments (the microfibril)[3, 17, 18] These vary in diameter from as great as 200 A in the crab leg muscles to about 80 A in insect wing muscles and are very long—certainly several microns. The basic fibrillar core of the myofilament (the protofibril) appears to consist of the protein actin, with which is associated a second protein, the myosin of the muscle. The reversible combination and dissociation of the actin and myosin are held to be the fundamental mechanism underlying contraction.[4]

In the development of muscle as a fiber the actin is clearly of basic importance. When extracted from muscle, it is well characterized as a globular protein of molecular weight of the order of 70,000.[4] In solutions of the appropriate salt (KCl) concentration it readily fibrillates to produce fine fibrils (protofibrils) closely resembling myofilaments.[3] This reaction is readily reversible and repeatable and provides one of the strongest arguments for the aggregation theory of fibrillation. It is clear, however, that the protofibril is not a simple linear aggregate 1 actin molecule wide, since the diameter of a corpuscle of molecular weight 70,000 is much less than the observed widths of the protofibrils. It may be necessary to suppose with Szent-Gyorgyi and Wyckoff a preliminary polymerization of several single actin molecules to give a larger particle, which then forms the linear aggregate. Insulin is a similar case, and the mechanism may be of wider occurrence. The work of Verwey and Overbeek again suggests reasons why a preliminary aggregation into a corpuscular form may switch over into linear aggregation as the aggregate reaches a certain size.[8] Particle size is well known to have critical effect on rate of coagulation. Rapid coagulation of an initially unstable colloid may develop into slow coagulation when the particles enter a certain range of size, resulting in conditions of stability, and Rees has shown that it is in coagulation from the *stable* condition that the aggregate takes the form of a long string of particles.[7] This is because it is in a stable suspension that the potential barrier surrounding a biparticle is lowest along the axis of the biparticle, which therefore represents the direction of easiest approach.

In the development of the higher structures in an actual muscle, tactoid formation may again initiate parallelism among the actin protofibrils, but owing to their continued growth to great lengths the lateral attraction resulting from colloidal forces will become overwhelming and produce a perfect parallelism, as in concentrated tobacco mosaic gels. As in such gels a hexagonal packing of the fibrils also develops. Local condensations and aggregations in such a system could lead to a system of parallel macrofibrils (myofibrils). The myosin, an independent protein, seems to become in part attached to the actin fibrils at regularly distributed sites, and partly to be loosely associated with the fibrils in the form of bands. The *Z*-bands of striated muscle are also deposited subsequent to fibril formation and to the initiation of contraction. The *Z*-band substance builds up at regular intervals, probably as a result of localized contractions. To discuss this more fully would go beyond the present intention. Tropomyosin, a probable precursor of myosin, also possesses the property of fibrillation to a marked degree. It seems to be very asymmetrical.

Cuticles and Membranes. These formations usually separate from a secretion onto an existing surface which is then able to exert an organizing influence. When fibrous in texture, they may exhibit considerable two-dimensional complexity relatable to the function of the membrane.

The peritrophic membrane lining the midgut of insects is an example of an extracellular membrane formed in many insects by delamination from the surface of the midgut cells. The electron micro-

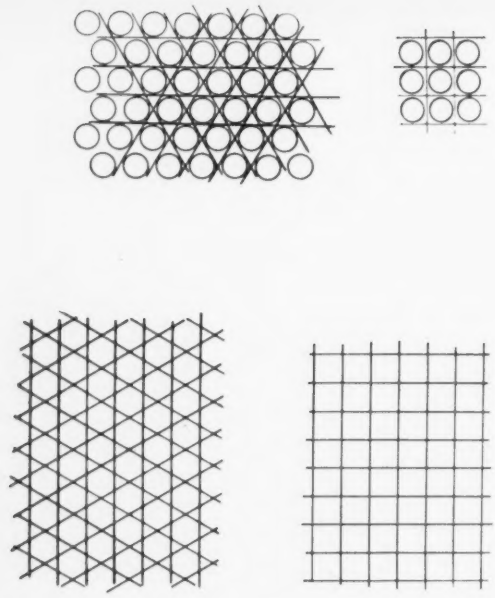

FIG. 3. Macrofibrillar arrangement of peritrophic membrane and its formation on a macromolecular template represented by hexagonal packing of particles at cell membrane.

scope shows that it consists of a succession of fine lamellae each of which is a fibrillar network of singular beauty.[19] When perfectly developed one finds a hexagonally symmetric network, such as drawn in Figure 3, consisting of three sets of fibrillar strands placed at 60° to each other. Each strand consists of several fine fibrils (protofibrils, probably chitin) randomly interwoven with the fibrils of other strands. Mechanically, the formation would be pliable but would resist deformation of a kind leading to mesh distortion. The fundamental structural unit is again a fine fibril, and the arrangement of these is similar to that which would result were a number of long, straight threads dropped at random and sorted out upon a surface bearing a hexagonal array of pegs. Such a formation suggests very strongly that the fibrillation has occurred in association with a surface bearing an appropriate hexagonal pattern—i.e., a template at the macromolecular level. We may suppose, for example, that the actual surface of the cells is formed by a close-packed array of spheres or cylinders (Fig. 3) and that the fibrils separate from the secretion and are deposited in the hexagonal array of grooves or channels.[19] Defective arrangements of fibrils may also be related to defective arrangements of the packing of the particles of the postulated template. In discussing cuticle formation, Picken, Pryor, and Swann[20] are inclined to reject theories of this sort on the ground that they imply a regular template extending over a vast number of cells. When the regular hexagonal packing shown by the ends of epithelial cells is considered, an ordered arrangement of this extension does not seem improbable. In fact, the cell packing may induce and orient the packing of the particles of the template surface as suggested by Figure 4.

In other cuticles, such as the earthworm cuticle studied by Rudall,[21] one finds sheets of parallel fibrils alternating with sheets having the fibrils at an angle somewhat less than 90° to those of the first set. Such a structure imposes something of the area-inextensibility and toughness of the peritrophic membrane structure, but is now deformable in shape and appropriate to allow of the animal's movements. Each large fibril seems to be a bundle of fine fibrils, and a feature notably different from the peritrophic membrane is that the large fibrils are contiguous, thus determining their own parallelism. Rudall has observed an apparently square array of large corpuscles in the lower layers of the cuticle. Fine fibrils have been noted also in chitinous cuticles by Ribi and by Mercer.

Plant Cell Walls and Cellulose. The formation of cellulose in the walls of plants is in some ways similar to the deposition of cuticles discussed above, although in this case the deposition is intracellular. Early electron microscopic studies of cellulosic materials revealed a variety of fine fibrils the diameter of which seemed to be related rather to the severity of the disintegration technique than to any significant structure. The use of more carefully chosen and handled material, however, such as the cell wall of *Valonia* and other growing cells,[22-24] has demonstrated the existence of definite, discrete fibrils, which must be considered as structural elements. For any one material the fibrils are very constant in diameter, but they may have quite

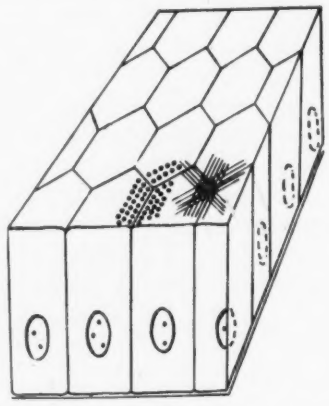

FIG. 4. Packing of particles forming macromolecular template in surface of hexagonally packed cells of columnar epithelium.

definitely different diameters in material from a different source. When reviewing this question Frey-Wyssling[23] has already pointed out the importance of these fine fibrils in the construction of the fibrillar texture. In plant slimes and in bacterial cellulose,[24] there is an absence of higher organization of the fibrils, pointing to an absence of an organizing template or other directive forces; in the plant cell walls on the other hand fibrillar organization shown by light studies has been confirmed and elaborated by electron microscopy. There has already been considerable speculation concerning the way in which cellulose could be deposited in the form of long chains, which need not be reviewed here since we are concerned with the alternative possibility of explaining these structures in terms of the protofibril as a morphological unit. The present theory leads to a view similar to that already expressed by Astbury and Preston[25] —i.e., that cellulose is synthesized intracellularly as a soluble "protocellulose," gathers at the periphery of the protoplast, and fibrillates. To account for the observed fibrillar organization, it is necessary to look either to an intrinsic pattern of the protoplast surface itself, or to a packing of the protocellulose particles themselves to form, as it were, their own template. The latter view is more in keeping with the present theory. It is significant that the first fibrils deposited in the primary wall show little interfibrillar order. Presumably owing to a low concentration of protocellulose particles, close packing is absent, and the fibrils as formed are deposited on the thin cuticular surface at random, leading to an irregularly interwoven formation. Subsequently, with more active synthesis, the development of close packing is forced by the dense gathering of the particles at the surface, leading to the possibility of ordered arrays of parallel fibrils. Taking for discussion the cotton hair, as shown in Figure 5, fibrillation apparently takes place in the packed array of particles along either of two preferred directions, which form a steep angle with the axis of the elongated cell, although occasionally a band of fibrils may be found encircling the cell horizontally, indicating a horizontal direction of fibrillation. The angle between the two favored directions is usually somewhat greater than the expected 60°. It is clear, however, that the theory can account for the many-layered structure of the secondary wall, for spiral formation, and for reversed spirals.

The relation between micelles and microfibrils of cellulose is of particular interest on account of the great amount of X-ray data available relating to the size of the micelles. In recent discussions[24, 26] it has been pointed out that it is not unlikely that the microfibrils are the structures responsible for X-ray diffraction, and that the fringed micelles may not be a necessary conclusion from the data.

A particle structure for cellulose has been proposed before,[27] but the present suggestion is distinguished from the earlier proposal in two respects: (*a*) The particles of the protocellulose here postulated are very much smaller than those demonstrated by Farr, whose hypothesis is definitely ruled out by electron microscopic findings, and (*b*) it is assumed that the identity of the particles is lost, when they fuse to form a protofibril, with the formation of what is, in effect, the system of parallel chains already inferred from X-ray data.

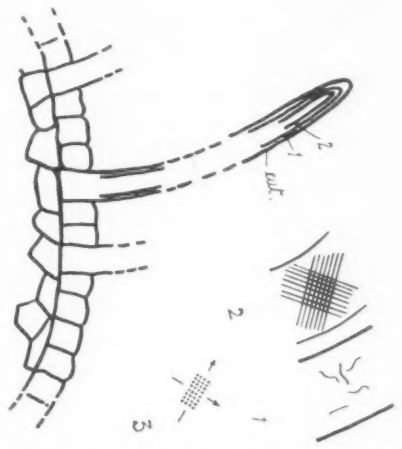

FIG. 5. Formation of primary layer (1) and secondary layer (2) by deposition of cellulose particles in cotton hair cell. At (3) is shown the postulated particle packing.

Collagen Fibers. Collagen fibers have been the subject of much electron microscopy on account of their striking banded structure.[3, 28] The existence of a discrete protofibril as the fundamental fibrous element has not been established, but this may be due to fibrillar splitting, owing to the rather weak lateral association between the long molecular chains themselves, as is demonstrated by the ease with which water enters and swells the intermolecular spacings. The indefinite fraying into an almost molecular fineness observed electron microscopically in swollen material may thus be in only apparent disagreement with the protofibrillar hypothesis. More definite and discrete collagen fibrils of rather large diameter (400–500 A) are observed in the sarcolemma of formalin-fixed muscle, and these may prove to be the immediate products of fibrillation. At present collagen seems to be an exceptional material and offers the least support for the theory advanced here. Recent work by Schmitt

and his colleagues implies that the banded structure arises from the regular distribution of a mucoprotein along a fundamental fibrillar structure in a manner reminiscent of deposition of the *Z*-band of striated muscle.

Insulin Fibers. Although fibrous insulin does not occur in nature, there are features about its formation that make it almost a model substance for the study of fiber genesis. It is formed simply by heating an acid solution and may be reconverted to the biologically active substance by treatment with alkali.[29] When formed slowly the fibrous form consists of indefinitely long protofibrils of diameter about 60–80 A which do not show a marked tendency to associate laterally.[30] When formation is rapid, spherulites, consisting of fine fibrils radiating from a center, appear. These seem to be formed by continuous growth from an initial center of fibrillar aggregation (Fig. 6). As Waugh has argued,[29] a linear aggregation of some kind explains most plausibly the development of the protofibrils and their easy reconversion to the corpuscular form. The submolecule of 12,000 molecular weight is the stable form in acid solution and is that which presumably aggregates. Since the protofibrils are much wider than the diameter of this molecule, we apparently must assume here, as was done with actin, a preliminary aggregation (polymerization) to a larger particle which then undergoes linear aggregation.

Silk Fibroin. The precursor of silk fibroin collects in a concentrated solution in the ripe silk glands of the silkworm and is converted into the insoluble fiber by extrusion through the spinnerets of the larva. This process is so closely analogous to the procedures of synthetic fiber manufacture that it may seem to support an "unfolding" theory. The precursor protein (fibroinogen), however, possesses the property of spontaneous fibrillation into fine protofibrils. This occurs in solution without mechanical disturbance and recalls the similar behavior of insulin and actin.[31] Solutions may also exhibit spontaneous birefringence. The development of the fiber is therefore better pictured as fibrillation, followed by a mechanically assisted parallelization of these preformed fibrils. No definite structures intermediate in size between the protofibril (*ca.* 100 A in diameter) and the final fiber have been discovered. This may be a consequence of the great speed at which the protofibrils enter into lateral association during normal spinning. The rate of spinning (1 cm/sec.) is much greater, for example, than the rate of growth of hair (1 mm/day), which is apparently slow enough to permit tactoid development.

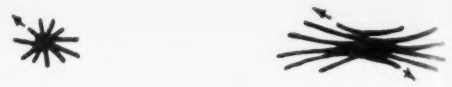

FIG. 6. End-to-end aggregation leading to formation of spherulites (growth from one center) and sheaf formation (growth modified by lateral attraction).

Fibrinogen and Fibrin. Fibrinogen is transformed into the fibrous fibrin simply by the addition of thrombin to its solutions. Electron microscopy reveals fine fibrils with a marked tendency to lateral association leading to tactoidlike forms and to areas of parallel fibrils.[32] Sheaflike formations indicative of continuous growth from a small aggregation of fibrils are common (Fig. 6). Definite macrofibrils are not observed. Fibrinogen has an elongated molecule and appears to aggregate laterally as well as end to end, but its conversion into fibrin remains an example of fiber formation which seems to demand the aggregation theory. There appear to be several fairly well-defined steps in the aggregation. The system of striations, which develop at right angles to the fibrillar direction when there is a sufficiency of thrombin, implies the existence of regularly distributed sites along the component fibrinogen molecules to which the thrombin becomes attached. This banding, however, does not seem to be necessarily associated with the basic fibrillation, as fibrils lacking bands have been observed (*cf.* collagen).

Synthetic Fibers. The above discussion has concerned only natural fibers. There is, however, a small amount of evidence to show that microfibrils also occur as distinct morphological units in artificially formed fibrous systems. Little attempt has been made to look for this type of structure, since the fringed micelle hypothesis has proved such a satisfactory model to account for the properties of these polymers. When directly sought, however, bundles of fine aggregated microfibrils have been discovered, proving the existence of a fine histology of some complexity.[33]

Summary

The very fine discrete fibrils found with the electron microscope in most fibrous materials of biological origin (carbohydrate and protein) probably represent definite "constructional units" from which the larger structures are built. Furthermore, from a consideration of the manner in which these fine fibrils or protofibrils are arranged—i.e., their geometrical relations in the higher structures—a plausible account can often be given of the way in which these larger formations have been elaborated.

It is postulated that the first step in the forma-

tion of fibrous structures is the synthesis of the nonfibrous precursor of the protofibril (primary synthesis); this precursor is next transformed into the protofibril (fibrillation); and the resulting fine fibrils are then organized into the higher forms. Two-dimensionally ordered arrangements seem to require a template at the fine histological level to control the deposition of the protofibrils. This may be provided by patterns on permanent cell surfaces, or by the packing of the particles of the precursor of the protofibrils, or by a fibrillar array already laid down. Three-dimensional arrays of parallelized fibrils—i.e., the typical fibrous form—appear to owe their formation to the lateral association of the protofibrils brought about by long-range colloidal forces. In systems of elongated particles or fibrils, these forces are known to effect and to sustain a perfect parallelism of the fibrils throughout large volumes. In planes at right angles to the long axis of the fibrils, a hexagonal arrangement develops. Localized aggregations and condensations of these arrays can lead to the types of macrofibril visible at the histological level.

The existence and the geometry of the protofibrils and their arrangement are matters susceptible to direct observation in the electron microscope, and conclusions drawn concerning structure at this level have therefore some reliability. On the other hand, the mechanism of the formation of the unit protofibrils themselves (fibrillation) can only be studied in an inadequate way by present techniques, and speculation cannot be so easily checked by experiment. In some instances where the isolation of the unaltered precursor has been effected, it has been shown *not* to possess a filamentous type of molecule, but to resemble rather the corpuscular types of nonfiber-forming compounds. This finding, and the apparent ease of the transformation into the fibrous state, point toward a linear aggregation of the particles of the precursor as the formative step without passing through an intermediate filamentous condition.

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Breeding of Small Fruits in the United States

GEORGE M. DARROW

The author, who is principal horticulturist in charge of the production and disease investigations of deciduous fruits at the USDA's Beltsville (Maryland) Plant Industry Station, has been making a survey of small-fruit research in northern Europe. His present article is based on his address at the International Horticultural Congress, held in London last September. Well known for his work in berry breeding and the genetics and polyploidy of fruits (see SCIENTIFIC MONTHLY, *72, 211 [1950]), he was the recipient of the Wilder Medal for the origination of notable small-fruit varieties and for his leadership in research in this field.*

IN THE United States the term "small fruits" is used much as is "soft fruits" in England, to contrast with tree fruits. It includes strawberries, raspberries, blackberries, blueberries, cranberries, currants, gooseberries, Juneberries, highbush cranberries, and usually grapes. Development of breeding programs for these fruits has depended in part on the importance of each in our agricultural industry. The farm values of our small fruits were as follows in the indicated years: grapes, $187,000,000 (1950); strawberries, $84,000,000 (1950); raspberries, $11,000,000 (1949); blackberries, $6,000,000 (1949); blueberries $5,000,000 (1949); cranberries, $8,000,000 (1950); and currants and gooseberries, $640,000 (1949). Currants and gooseberries are cultivated relatively little in the United States as compared to North European countries, but blueberries, cranberries, and blackberries are relatively more important than in Europe. The very extensive culture of the vinifera grapes as a highly concentrated industry in California is also somewhat characteristic. Some small fruits, however, are raised in every state.

The development of breeding programs has depended on the needs of the industry and the urgency of those needs, as well as on an appreciation of their urgency. Latham red raspberry, for example, resulted from a breeding program to obtain a good hardy variety for Minnesota, where most other varieties are not hardy. The Cardinal grape resulted from a breeding program to obtain an early variety that would stand shipment from California to Eastern cities. The Temple strawberry was bred to fill the need for a red stele disease–resistant shipping variety for the low-lying soils of eastern Maryland and adjacent areas, where the disease had killed the older varieties. These objectives were practical ones, and by far the major part of the breeding work in the United States has very practical objectives similar to that of the strawberry breeding work of R. D. Reid in Scotland. Other examples of specific practical objectives of our strawberry breeding programs are breeding firm berries for the Southern states for shipping long distances to market, extremely hardy varieties for the Great Plains area where the temperatures go to −40° F., and varieties especially adapted to the freezing industry.

The breeding work with small fruits is now largely done by governmental agencies—that is, by state and federal research stations. In addition to government agencies, however, there is one notable private agency—the California Strawberry Institute—that is breeding strawberries for its members. Many private growers and a few nurseries are still breeding small fruits, but their work is relatively limited and often lacks the continuity of governmental research.

Origin of the Older Small Fruit Varieties

The older small fruit varieties grown in the United States, which were important before 1930, had various origins. All the older vinifera grape varieties are direct importations from Europe, North Africa, and southwest Asia. All older muscadine grape varieties are selections from the native wild species. Most of the older *labrusca*-type, or American bunch, grapes resulted from the work of such notable private breeders as E. S. Rogers and T. V. Munson. Early basic strawberry varieties came from England and France, but until about 1930 all commercial varieties were from private

Left, Temple, the first strawberry bred for resistance to red stele root disease; right, Blakemore, nearly killed out by this disease.

breeders in the United States, including both those making actual crosses and those raising seedlings without controlled crossing and from selections from the wild. The older red raspberry varieties were importations from Europe; later most varieties came from natural hybrids of European varieties with selections of the native American red raspberry. All older black raspberries were selections from the wild, and the later ones were the result of private breeding work. All the older erect-growing blackberries were selections from the wild, the Himalaya (Theodor Reimers) and Oregon Evergreen (parsley-leafed) were direct introductions from Europe, and only the Logan and Young came from private breeders. The older currant varieties were all of European origin; later, American selections of seedlings of European varieties and selections resulting from actual crosses replaced most of those originating in Europe. The older gooseberries were also of European origin, but seedlings and crosses of the European varieties with native American species raised in America mostly replaced them. All cranberry varieties, until very recently, were selections from the wild.

New Varieties

In 1930, except for the Latham raspberry, no small fruit originated by a government agency was of appreciable importance, yet by 1950 new varieties originated by such agencies produced about 55 per cent of the strawberry crop, 95 per cent of the red raspberry, 50 per cent of the purple raspberry, 30 per cent of the black raspberry, 5 per cent of the blackberry, 90 per cent of the blueberry, and 2 per cent of the grape. Many recently introduced varieties have not yet reached their full importance. Because of the selections and materials in the hands of breeders and because of their background of experience and their accumulation of superior germ plasm, the rate of introduction and the value of new varieties being and to be introduced may be expected to increase constantly. Following the success of the breeding work in the past twenty years, many new breeding projects have been started to correct various weaknesses in present varieties.

A survey of some of the qualities of the new commercial varieties will indicate why they have been successful. The Seneca and Fredonia grapes are good varieties, ripening much earlier than the Con-

cord, the standard variety of Northern states. Seneca is not only about a month earlier than Concord but one of the finest of all grapes. The Cardinal grape is earlier and the Calmeria is later than any other satisfactory vinifera varieties suitable for shipping. Burgaw, one of the first perfect-flowered muscadine grapes, is a good variety. The Temple and Sparkle strawberries are resistant to the red stele root disease; the Massey and Shasta are large-fruited varieties; the Blakemore is firm-fruited for shipping and excellent in color and flavor for preserving and ice cream coloring and flavoring; the Klonmore is resistant to leaf spot and adapted to the short days in the South; and the Sioux withstands temperatures down to −40° F. without being covered with a protective mulch. Among the red raspberries the Washington and Willamette varieties were bred for hardiness in the fall in Oregon and Washington—that is, their buds stay dormant in the fall when the Cuthbert variety starts growing again and is killed back by fall freezes.

Extent of Small-Fruit Breeding Program

W. H. Alderman in 1947 surveyed the fruit breeding work in the United States. At that time, 24 state and federal stations were reported as having projects for breeding strawberries; 16, raspberries; 9, blackberries; 12, blueberries; 2, cranberries; 16, grapes; 3, currants; 6, gooseberries; 1, high-bush cranberries; and 2, Juneberries. These projects, of course, are carried on at various levels of intensity. Some are minor in extent, and others may be the equivalent of a score of lesser projects. Among the more important grape projects are those with vinifera grapes at the experiment stations at Davis and Fresno, California; with muscadine grapes at Raleigh, North Carolina; Griffin, Georgia; and Meridian, Mississippi; and with bunch grapes at Davis; Blacksburg, Virginia; Meridian; Stillwater, Oklahoma; Mountain Grove, Missouri; Urbana, Illinois; Geneva, New York; and Beltsville, Maryland.

Among the stations with active well-established strawberry breeding programs are those at seventeen locations: Orono, Maine; Durham, New Hampshire; Geneva; Beltsville and College Park, Maryland; Raleigh; Jackson, Tennessee; Baton Rouge, Louisiana; Lexington, Kentucky; South Haven, Michigan; Columbia, Missouri; Madison, Wisconsin; St. Paul, Minnesota; Cheyenne, Wyoming; Puyallup, Washington; Corvallis, Oregon; and Davis.

A quick test for resistance to red stele root disease is obtained by growing seedlings, 64 to the square foot, in greenhouse benches in winter and discarding all susceptible ones before planting time in the spring. Years of time can be saved by this means, and as many as 35,000 seedlings reduced to 6000–8000 for field testing. Note dying plants in bed to the right.

There are well-established projects with red raspberries at ten locations: Durham; College Park and Beltsville; Raleigh; Blacksburg; Knoxville, Tennessee; St. Paul, Minnesota; Puyallup; Corvallis; and Davis; with black raspberries at four institutions: Geneva; College Park; Ames, Iowa; and Raleigh; with blackberries at Geneva, Beltsville, Raleigh, and Corvallis.

The work with currants, gooseberries, Juneberries, and high-bush cranberries is minor at the present time.

Blueberry breeding is an important project at South Haven, Michigan; Durham; and Beltsville; and cooperatively by federal and state stations in New Jersey, North Carolina, and Georgia. Cranberry breeding has been active at the Long Beach Station at Washington and cooperatively by the federal and the New Jersey and Massachusetts stations.

The results of these extensive breeding programs have fully justified their establishment as judged by the usefulness of the varieties already introduced. Table 1 shows, as nearly as can be ascertained, the numbers of varieties that have been introduced by state and federal experiment stations since 1920.

TABLE 1

Fruit	1920–29	1930–39	1940–49	1950–52	Total	Of Some Importance
Grape	54	22	39	4	119	20
Strawberry	23	19	37	6	85	26
Raspberry	15	16	7	2	40	20
Blackberry	0	2	6	3	11	5
Currant	4	6	1	0	11	2
Gooseberry	14	3	0	0	17	4
Blueberry	7	11	4	4	26	21
Cranberry	0	0	0	3	3	0
Total	117	79	94	22	312	98

Of these 98 varieties of more or less importance, the Latham, Washington, Willamette, and Taylor red raspberries; the Bristol black raspberry; the Blakemore, Klonmore, Catskill, Shasta, Temple, Sparkle, and Massey strawberries; the Red Lake currant; the Hunt, Burgaw, Fredonia, and Cardinal grapes; and the Cascade and Olallie blackberries have made the greatest impression within their respective fruit industries. The entire blueberry industry is based on the breeding work of the late F. V. Coville, of the U. S. Department of Agriculture.

Workers at the Louisiana Station developed a method of mass inoculation of strawberry seedlings by spraying them with spores of the leaf spot fungus so as to eliminate readily susceptible ones before planting them in the field. Geo. F. Waldo, in Oregon, developed a method of growing strawberry seedlings in infested soil in greenhouse benches in winter to eliminate quickly those susceptible to the red stele root disease. The seedlings are set 64 to the square foot in August or September, and by December the beds are flooded and the temperatures are lowered to enable the red stele fungus to infect susceptible plants. The resistant plants are then set in the field for fruiting. Hundreds of thousands of seedlings have been put through the test.

The Temple strawberry bred for red stele resistance is now the principal variety raised on the Chesapeake Peninsula.

Recently a greenhouse bench test for susceptibility to black rot of grape seedlings was reported by the Urbana (Illinois) Station. Use of the correlation of glaucousness of the leaf of the southern blueberry *Vaccinium ashei* with blueness of the fruit at the Georgia, North Carolina, and Beltsville stations has made possible the discarding of dark-fruited seedlings when they are 12–18 inches high and before they are planted in the field. Already the test has been used on tens of thousands of plants.

Thorniness in blackberries has been found to show up on very small seedlings in seed flats, and in breeding for thornlessness at the Beltsville Station most of the thornless ones can be separated at that time.

R. B. Wilcox, in New Jersey, designed a feeding test for the leaf hopper that transmits the false-blossom virus of cranberry. He had found that the varieties freest from false blossom were also the ones fed on least by leaf hoppers. By exposing leafy cuttings of the selected seedlings to the feeding of 50 leaf hoppers, the relative palatability of the selections to leaf hoppers was determined, and

the least palatable ones were considered as the best, other characters being equal.

Glenn Huber, in Washington, designed a feeding test for the raspberry aphid that transmits raspberry viruses. Plants, or growing shoots in water, were placed in the greenhouse, and aphids were transferred to them. Feeding on seedlings and selections compared with that on standard varieties was found to be a good measure of their resistance to virus infection. Susceptible varieties when selfed gave only seedlings susceptible to vector feeding and were homozygous for this character. Resistant varieties when selfed gave a high proportion of resistant seedlings, indicating that resistance was dominant.

These various methods of mass selection have enabled breeders to handle far more material and to advance their work more rapidly than otherwise. We need other quick mass-selection tests for use by breeders. For instance, we need to learn how to distinguish the perfect-flowered muscadine grape (to be saved) from the pistillate-flowered as very young seedlings. Now breeders are forced to grow seedlings up to flowering age and then discard the pistillate ones. In addition to the black rot–resistance test mentioned previously, we need for grapes quick tests for anthracnose- and mildew-resistant selections. A stem canker–resistance test for eliminating all susceptible blueberry seedlings when they are small would be very helpful. A test for low-temperature hardiness of blueberry buds also would help greatly in selecting hardy blueberries.

Breeding work in the United States has, of course, been very greatly helped by background research in systematic botany, cytology, and genetics. Part of such basic work has been done by breeders and part by other scientists. Much background work has, of course, also been done by workers in other countries and in other lines of research.

Our knowledge about the genus *Rubus* has been greatly increased in recent years as the result of the cytological work of H. E. Fischer, S. W. Brown, S. H. Yarnell, and John Einset and the breeding work of Geo. F. Waldo, in Oregon, and of workers at our Beltsville Station based on such knowledge. LeRoy Powers, of Wyoming, and D. H. Scott, at our station, have added to our working knowledge of the genetics of strawberry. H. E. Fischer and Haig Dermen, by their cytological research, and W. H. Camp, by his systematic work, have helped to make the cluster-fruited group of blueberry understandable.

Small fruit breeders have been greatly helped by a series of informal field meetings at fruiting time. These began in 1929 with a strawberry meeting. In some years no meetings are held and in others there are two or three. This year, for example, a strawberry meeting was held to review practical breeding, the genetics, and the virus-free propagation of selections at Beltsville and College Park. A blueberry meeting was held at Tifton, Georgia, to review the work in Southern states, and a raspberry meeting at Geneva. These proved stimulating to research workers.

A useful rating system for all kinds of berries has been adopted by many small-fruit workers, as well as by workers with other crops. Each character is rated from 1 to 10, with 10 the best and 6 as the lower limit of acceptability. Thus, for strawberries, production, large size, firmness, flavor, color, uniformity of size and of shape, and resistance to leaf spot, to leaf scorch, and to red stele are each so rated.

Blackberry and Raspberry Breeding

The fine flavors of the Logan, Young, Boysen, Cascade, Chehalem, and Olallie blackberries have been derived in part from native western American species. Fischer determined the chromosome number of many blackberry varieties, hybrids, and native selections from the Pacific seaboard area, and S. W. Brown made a detailed survey of the range of the different chromosome types in the wild species in California. Waldo successfully used this western blackberry group not only to obtain the nine-ploid Cascade, the six-ploid Chehalem, and the six-ploid Olallie varieties, but also crossed blackberries of different high chromosome numbers (mostly 6*x* or higher) to obtain a whole series of promising productive selections. Waldo's crosses of native western American octoploids with the eastern tetraploid blackberry and with the tetraploid raspberry to obtain new horticultural forms were based on the cytological work of Fischer and Brown and, of course, also on the older work of M. B. Crane and P. T. Thomas, in England. It is possible now to obtain hundreds of forms of blackberry types related to the Logan.

In Texas, S. H. Yarnell studied backcrosses of the tetraploid Nessberry, a raspberry × blackberry cross, to blackberries and raspberries. The Nessberry 4*x* × the 4*x* Lawton blackberry gave seedlings containing the chromosome series 2*x*, 3*x*, 4*x*, and 5*x*, not just 4*x*. A cross of the 4*x* Nessberry with the diploid wild dewberry resulted in very large-berried plants and named varieties, all being diploid dewberries, with but little raspberry showing in their make-up.

In the East, John Einset made an extensive survey of the chromosome numbers of over 1600 seed-

lings of blackberry varieties and of native blackberries near Geneva, New York, these having 21, 28, 35, 49, and 63 chromosomes. In contrast to Waldo's breeding work, in which he intercrossed many varieties with high (6*x* to 12*x*) chromosome numbers and obtained no observable maternals, and also in contrast to S. H. Yarnell's experience, Einset reported that triploid to nine-ploid plants, including both species and horticultural varieties, produced 80 to 100 per cent apomictic seedlings.

Although apomixis, as reported by Ake Gustafsson and others for European species of *Rubus,* apparently occurs to some degree in American blackberries, its extent is still unknown; however, it may sometimes interfere with the improvement of this fruit.

Red and black raspberry breeding at many stations is concerned with recombining their desirable genetic qualities to obtain superior varieties within the species. Work on hybrids between the red and the black, with later backcrossing and segregation, is also under way. Because of the variability of red and purple raspberries, extensive work with both types is still needed, especially in segregating out qualities of the purple hybrids.

A major project in raspberry breeding is that of C. F. Williams, of North Carolina, who has used several foreign species, including *Rubus biflorus, R. coreanus, R. kuntzeanus,* and *R. parvifolius,* in crosses with American red and black raspberries. Because American raspberries are not adapted to the Southeastern states except at the higher elevations, Williams has tested some 40 introduced raspberry species. The four above-mentioned species seemed most promising for breeding. Williams hybridized these four with American raspberries, backcrossed selections of the F_1 to American varieties and then repeated the backcrosses. Several of these foreign species have been intercrossed, and selected hybrids have been used also. Resistance to disease, heat, and drought, small seed, early to late ripening, firm and large fruit, great vigor, and productivity are some of the desirable qualities to be obtained from these species. Although only two varieties, the Dixie (involving *R. biflorus*) and the Mandarin (involving *R. parvifolius*), have been introduced so far, this work is continuing on a considerable scale.

Strawberry Breeding

Tests of the response of strawberry varieties to length of the daily light period have furnished the basis for the adaptation of varieties to different parts of the United States. We know that the Missionary variety makes fruit buds and fruits more freely than other varieties in Florida and that Dunlap, Howard 17, and other northern varieties fail in Southern states. Responses to temperatures are nearly as great as to the daily light period. Royal Sovereign and Climax have little trace of their fine flavor when grown in the warm climate of Maryland. Strawberry breeding seems to be carried on best in the area where the resulting varieties are to be grown.

The finest flavors in our strawberries have come from the hybridization of *Fragaria chiloensis,* native to the beaches of the Pacific Coast of the Americas, with *F. virginiana,* native to the eastern United States. The standard of flavor was for a long time that of the Marshall variety as it grows in western Oregon. Like the Royal Sovereign, Marshall has poor flavor when raised in the warm climate of Maryland. Several other varieties have high flavor under certain conditions—the Rockhill in Minnesota and the Fairfax and the Dorsett in eastern states south to Maryland and Virginia. Suwannee, however, a home-garden variety, has perhaps the finest flavor of all in much of the eastern United States, especially in eastern Maryland and Virginia under relatively high temperatures, where Royal Sovereign and Marshall rank very low in flavor. Suwannee resulted from a cross of Howard 17 and Missionary, the same cross that produced the Blakemore, our most extensively grown variety. Blakemore has fair flavor only. Bellmar, a little-grown variety, and Tennessee Beauty, a variety of the same parentage widely grown in the area Maryland to western Tennessee and Kentucky, have better flavor. Recombining desirable genes in an octoploid fruit like the strawberry has been a productive practical breeding project, and its possibilities seem very great.

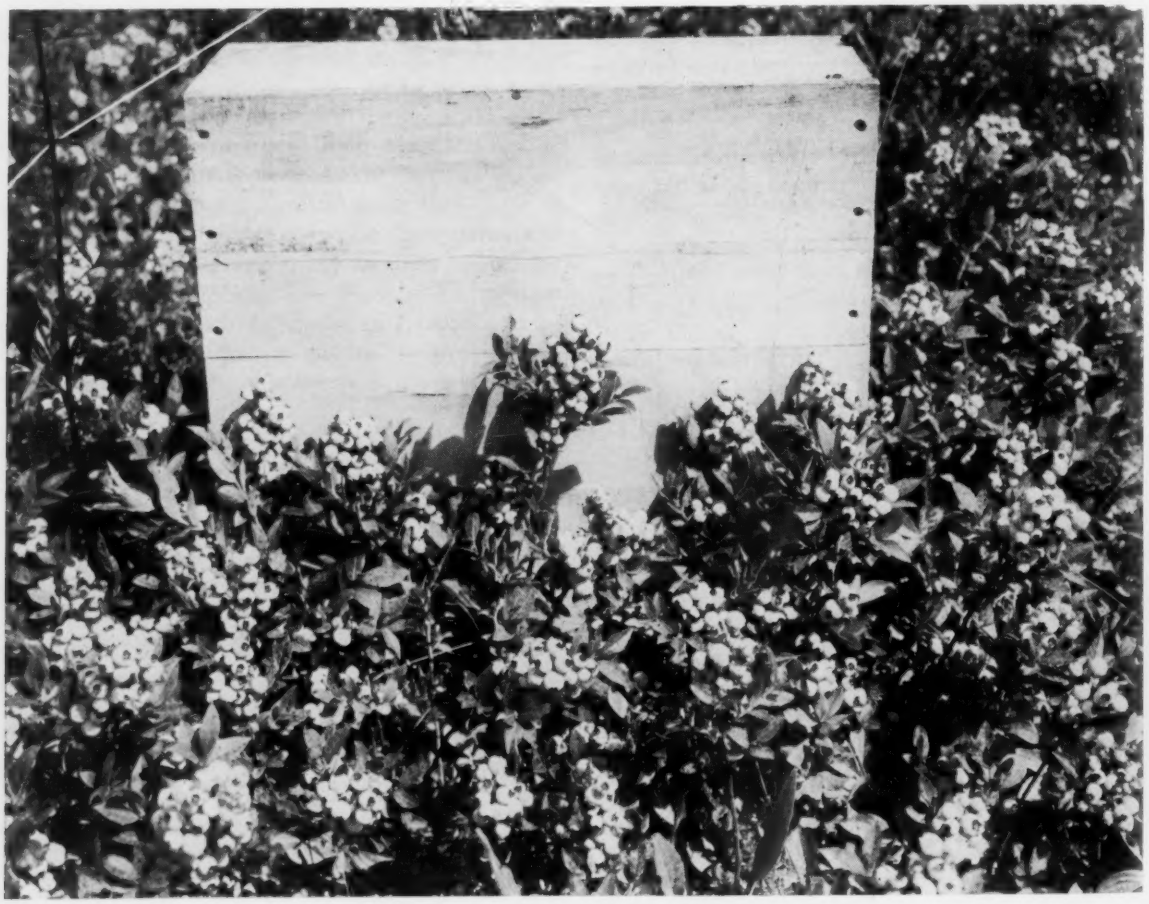
Studies of the ascorbic acid content of parent and seedling strawberries indicate that this characteristic is inherited and that varieties with high ascorbic acid content can be bred for any area. Studies of frost resistance of flowers have shown the possibility of obtaining varieties of which the flowers will withstand frost down to 18° F. Reference has been made to breeding red stele root disease–resistant strawberries and varieties with various desirable fruit qualities. In all breeding work, preserving and freezing qualities are also considered. For preserving, uniformly colored light-red, high-flavored, tart, firm berries are best, and for freezing, deeper red, high-flavored, tart, firm berries are liked.

LeRoy Powers, in Wyoming, where minimum temperature is an absolute limiting factor in grow-

ing strawberries, reported studies involving crosses between cultivated varieties and the native species, *F. ovalis,* hardy to – 40° F. A high degree of winter hardiness, production of many runners, and a short period from first bloom to first ripe fruit were dominant over their opposites. In 31 of 45 possible cases, the characters studied were independently inherited. Only in number of days from May 1 to bloom and number of days from bloom to ripe fruit did genetic linkage reduce the number of seedlings combining the desirable characters. On the average one seedling in one hundred recombined the more desirable characteristics. D. H. Scott, at Beltsville, has studied tetraploid *F. vesca,* hexaploids derived by crossing the tetraploid *F. vesca* with the cultivated strawberry, and decaploids and other polyploids derived from crossing the hexaploids with a cultivated strawberry. The hexaploids, though vigorous, were nearly sterile. The decaploids, with two genoms from *F. vesca* and eight sets from the cultivated, were relatively fertile, and some have the high aroma characteristic of *F. vesca.* Additional relatively fertile decaploids have been obtained by crossing decaploid × decaploid.

Blueberry Breeding

Much work remains to be done on the botany and cytology of the blueberry. There are three homoploid groups, diploid, tetraploid, and hexaploid, and all homoploids of the subgenus to which the cultivated blueberries belong are relatively interfertile. Camp has listed 24 cluster-fruited species, mostly of eastern North America from tropical southern Florida to arctic northern Canada; 9 are diploids, 12 tetraploids, and 3 hexaploids. The polyploids may be auto- or allopolyploids. Some species, like the low-bush tetraploid *Vaccinium lamarckii,* seem to be vigorous autopolyploids of *V. angustifolium.* Others, like the tetraploid *V. alto-montanum,* seem to be a complex containing



Surveys of native stands such as this of low-bush blueberries in Massachusetts and in New Hampshire indicate that they are not pure low-bush but millions of segregates of hybrids between the low-bush and high-bush species. In such areas can be selected the plant types best suited for man's use. Breeding such plant types with large, fine-flavored fruit is the job ahead for parts of the northern United States.

Brooks, the original highbush variety selected by the late F. V. Coville in New Hampshire and used extensively by him in breeding. The varieties establishing a cultivated blueberry industry in the United States resulted from Dr. Coville's work.

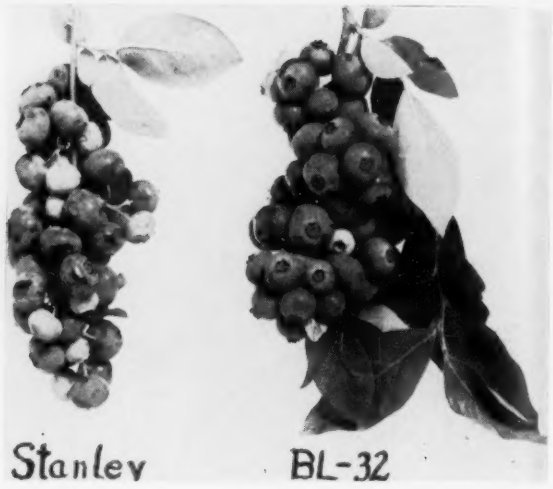
autopolyploids of *V. vacillans,* as well as allopolyploids of *V. vacillans* crossed with several other species. The hexaploid rabbiteye, *V. ashei,* is likewise a complex, probably containing both auto- and allopolyploids. Their complicated genetic origin makes them highly useful to the plant breeder.

In the earlier breeding work of Coville, 3 tetraploid species were used—*V. australe, V. corymbosum,* and *V. lamarckii.* More recently 13 of the 24 species were used for their horticultural characters, several of them extensively. Still other species have been hybridized in genetic studies, and some of the natural hybrids between species in the wild have been collected. They provide a wide range of desirable horticultural qualities. In addition to the 12 tetraploid species listed by Camp, a series of additional tetraploids has recently been made by crossing the hexaploid species *V. ashei* with 5 diploid species. The first of these artificial tetraploids (*V. ashei* × *V. tenellum*) proved to be fully fertile in crosses with the tetraploid cultivated varieties, and the seedlings seem to have the desired combination of qualities—earliness for the southern United States and heat and drought resistance for the more northern areas. Other diploids are being used in breeding: *V. darrowi* for its blueness of fruit, *V. atrococcum* for its earliness and vigor, *V. vacillans* for its adaptation to uplands, and *V. elliottii* for its earliness and adaptation to the least acid soils. This has seemed a useful approach in greatly extending the genetic basis of improvement of this fruit.

The actual hybrids between various species have helped in the interpretation of the tens of thousands of acres of wild blueberries from which the fruit is harvested in Massachusetts and New Hampshire. We now know that the millions of plants in these and other similar areas are segregating populations of high-bush × low-bush parentage. We can observe the height, spreading habit, and branching of the plants, their leaf size and shape, their fruiting habit, and the color, size, flavor, firmness, and picking qualities of their fruit as indications of the

Left, Rubel, the best variety selected from the wild; right, Berkeley, the largest and lightest-blue blueberry resulting from breeding work up to 1952.

Left, the new Bluecrop, a very hardy variety; designed to replace Stanley, a standard medium-early variety. Bluecrop is hardier, with large, light-blue fruit.



Right, Ivanhoe, a new early, high-flavored, somewhat larger and more disease-resistant blueberry than Stanley.

type of selection to be made in breeding for new types. Similar millions of segregates of several other species hybrids are to be found in other areas and are useful in interpreting the results to be obtained in breeding with such species. Some of these millions of wild plants we can easily interpret because of their location in relation to parent species. Thus, the hybrids of *V. vacillans* × *V. tenellum* along the boundary of the Coastal Plain and Piedmont regions of North and South Carolina are readily recognized. Additional studies are needed, however, to interpret the method of origin of extremely variable populations of the rabbiteye and related blueberries of southern Georgia and northern Florida.

Cranberry Breeding

The first cranberry breeding began in 1929 because of the need for varieties resistant to false blossom. Because this disease is the most important one in Massachusetts and New Jersey, the highly resistant variety Early Black is being planted and constitutes most of the crop. Some thousands of seedlings of cranberries have been grown in this work, and about 150 selections have been made. Most of these have been given a feeding test for the leafhopper vector, and the selections least fed on by the leaf hopper are considered least likely to acquire the disease. The three varieties named and introduced—Beckwith, Stevens, and Wilcox—have greater productiveness than Early Black, and one —the Wilcox—seems as resistant to feeding by the vector as Early Black.

A second line of cranberry breeding is that of Haig Dermen. He has doubled the chromosome number of all the important varieties and then selfed and crossed a few of the tetraploids. Some of these were expected to fruit this fall. Doubling the chromosome number of the varieties also made it possible to hybridize them with a far northern hardy species that seems highly resistant or distasteful to the vector.

Grape Breeding

Three types of grapes are grown commercially in the United States—muscadine, bunch, and vinifera. The muscadine grape is native to the Southeastern states. It has two more chromosomes (40) than other grapes (38) and does not cross readily or produce fertile seedlings with other species. Grapes of this species are harvested somewhat like plums, each berry coming off the stems singly. The species requires a long growing season, longer than that in Washington, D. C., where it does not always mature. The sexes are borne on different plants, and breeding in recent years has been directed toward the production of a series of perfect-flowered varieties to replace the pistillate ones, which require a male vine near by for pollination. Although several perfect-flowered varieties have been named, only one good variety—Burgaw—has been produced. Some 250 other perfect-flowered selections are under test.

Other varieties have been originated from the bunch grape species, native to the eastern United States. They have many fine horticultural qualities that will take a long time to recombine in one or in several best varieties. Moreover, they are readily hybridized with the vinifera grapes, so that the fine qualities of that species can be included also. Good

varieties have been introduced in Minnesota—where the temperatures go to – 40° F.—and other varieties in Texas, a thousand miles to the south—where the summers are long and hot. Recent work with bunch grapes has been done to obtain varieties with the high flavor, firmness, and shipping and storage qualities of the vinifera, combined with productiveness and the unfermented juice qualities of the Concord, as well as with the black rot and mildew resistance of some of the native species. There seem to be no barriers to intercrossing the native species, all being diploids.

Extensive work in breeding vinifera grapes in California has been relatively recent. The work at Fresno has been directed toward the production of superior commercial table varieties, as exemplified by the Cardinal, the earliest commercial variety, and Calmeria, the latest. The work at Davis includes breeding for superior wine grapes, as well as for table grapes, and some varieties have been introduced. Notable work at Davis is being done with tetraploids. H. P. Olmo, of that station, has collected giant-fruited sports and varieties of both vinifera and bunch grapes through nearly a score of years, has found them to be tetraploids, has crossed them to produce large-fruited seedlings, and has already named one of his tetraploid seedlings. His work with polyploid grapes is further along than that with other polyploid fruits. So far, increase in fruit size and availability for crossing are the most notable characteristics of these polyploids, but increase in stem and foliage weight may also be important.

Rake used for harvesting low-bush blueberries.

The Herbert, to be introduced next month, averages a little larger than the Berkeley and is not only the largest but the finest-flavored of all varieties in the trade.

Because of the success of the small-fruit breeding work in the state and federal experiment stations of the United States, the work is steadily expanding and becoming better. Extensive recombination of desirable qualities in commercial varieties has been remarkably successful in improving small-fruit varieties, but much more needs to be done. A beginning has been made in the use of the many related species of each fruit; there are related species with great reservoirs of desirable qualities that can make each small fruit many times as useful as at present. A bare beginning has been made in the use of polyploidy in the improvement of small fruits. The great increase in fruit size of tetraploid grapes is especially interesting and suggests many changes and improvements in our fruits based on the use of this new tool.

SCIENCE ON THE MARCH

ICE ISLANDS IN ARCTIC RESEARCH*

FIG. 1. General view of original campsite on T-3. White strip at top of picture is salt sea ice.

THE first information regarding the existence of ice islands was supplied by USAF reconnaissance flights in the late summer of 1946. Regular weather flights over the Arctic Ocean had been started in July of that year, and it was the radar observer on one of these missions who first pointed out a large mass, about 200 square miles in area, which at first appeared to be an island in the usual sense of the word. Its existence was for a time kept secret, and the object was given the enigmatic name "Target X."

On subsequent flights the location of Target X was seen to change, and it was concluded that this was no ordinary island but a huge floating sheet of ice. Its course was carefully followed for the next three years. During that time it traveled northeasterly from a point 300 miles north of Point Barrow, Alaska, to a point about 150 miles from the geographic pole; it then began a southward movement toward Ellesmere Island.

In the meantime arctic weather reconnaissance flights became routine operations, and crews were instructed to search for other ice islands. In July 1950 two more floating islands were discovered in quick succession. They were designated "T-2" and "T-3," and Target X became "T-1."

Island T-2 was located about 250 miles south of the pole. During the following winter it passed over the pole and headed toward Greenland. In the late summer of 1951 it had passed beyond the range of the weather reconnaissance flights from Alaska and is probably located in the East Greenland area at present. If this mass of ice gets caught in the East Greenland Current, it is possible that its journey will be rapidly accelerated toward the North Atlantic shipping lanes.

The island known as T-3 was discovered west of the point at which T-1 was first observed. It, too, followed a northerly course, later changing to

* The research reported in this paper has been supported by the Geophysics Research Directorate of Air Force Cambridge Research Center, Air Research and Development Command.

southeasterly. In March 1952 it was located in the vicinity of Lat. 88° N and Long. 130° W.

In relative size T-1 was the largest island and probably the oldest, as its surface was quite smooth. From aerial photographs the islands seemed to be characterized by an absence of sharp pressure ridges. Instead, they appeared to consist of low rolling valleys and hills, 15–20 feet high and spaced about 200 yards from crest to crest. These smooth ridges were apparently more pronounced on T-3. It was assumed that this island was younger and had passed through fewer cycles of the leveling process brought about by successive melting and freezing.

The desirability of landing on the ice islands became increasingly apparent to the people engaged in arctic weather forecasting. The Arctic Ocean had always been one of the largest areas on earth from which observations were scanty. The ice islands appeared to be stable platforms free from danger of breakup, and they were located in geographical areas that were entirely without continuous meteorological records.

During this period, Lieutenant Colonel Joseph Fletcher was commanding officer of the 58th Reconnaissance Squadron, whose primary mission was the gathering of weather information. As commander, Lieutenant Colonel Fletcher, a pilot and a trained meteorologist, was one of a group that ardently desired the establishment of a permanent weather station in the Arctic Ocean. Fletcher, with the ice islands in mind, obtained the support of the Alaskan Air Command and started to organize a small landing party. The drift course of T-3 and its probable future location made it the most desirable target for landing operations during 1951–52.

In the interests of economy and the maximum utilization of personnel, the number of the island's proposed residents was limited to eight, not including, of course, any wildlife that might be encountered. Approximately fifteen tons of equipment were sent to an Air Force base in Greenland. Most of this equipment was packed for parachute drop, with the more delicate items to be landed by aircraft.

A C-47 of Flight D of the 10th Air Rescue Service landed on T-3 March 19, 1952, with Major

FIG. 2. Jamesway living quarters and working space on T-3 in June 1952. Snow cave containing supplies in foreground.

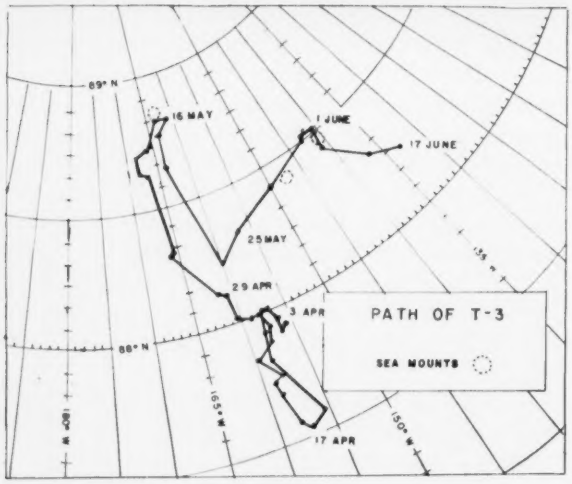


FIGURE 3.

General Old, of the Alaskan Air Command, leading the party. Three men—Lieutenant Colonel Fletcher, Kaare Rodahl, of the Aeromedical Laboratory in Fairbanks, and Captain "Mike" Brinegar, veteran polar navigator—remained on the island. Approximately a week later Albert Crary, of the Geophysics Research Directorate, Air Force Cambridge Research Center, and Captain Paul Green, communications specialist, were flown to T-3. They were soon followed by other supporting personnel, and the work of establishing a weather station progressed rapidly.

Three Jamesway shelters provided laboratory space, living quarters, and kitchen facilities (Figs. 1 and 2). Most of the equipment was stored under tarpaulin covers in snow caves. Large quantities of drum stock—gasoline, oil, and diesel fuel—were paradropped onto T-3 from a C-54 of the 10th Air Rescue Squadron. A small oil-fired kitchen range was used for cooking, and heating was accomplished by various types of oil stoves and space heaters, which proved entirely adequate. Valuable information was obtained on the most suitable types of heaters, clothing, sleds, power generators, etc., for such an operation as "Project Icicle," as the landing was designated.

Regular U. S. government "5-in-1" rations were parachuted onto the island and served as emergency food supply. A wide variety of canned goods and fresh meat provided the daily food requirements. Meat and bread remained frozen as long as they were kept in the outdoor food locker, and virtually no spoilage resulted. During the first few weeks of the occupation, water for drinking and washing was obtained by melting snow. A better source of water was soon discovered, however. While drilling through the ice to obtain cores for strength and salinity analyses, an under-ice lake was discovered. Liquid water to a depth of 3 feet was trapped under ice about 8 feet thick. This source of water was located in a valley and apparently resulted from the melting of ice and snow during a preceding summer. During the warm season the valleys fill to a depth of several feet, and when the temperature falls the lake freezes from the top downward. The rate of freezing decreases with increasing ice cover above and soon slows to such an extent that the residual water remains liquid for long periods of time.

The primary purpose of the ice island expedition was to supply regular and reliable weather information. Meteorological data are currently being collected by personnel of the USAF Air Weather Service and rawinsonde reports are sent out by radio every six hours. Two weather men and two radio men are engaged in this work at present.

Also of great importance is the program of scientific investigation being carried out by members of the Air Force Cambridge Research Center. This work is under the direction of James A. Peoples, Jr., of the Terrestrial Sciences Laboratory, Geophysics Research Directorate.

During the first three months of the island's occupation, more than 250 observations of the position of the sun and moon were made. These astronomical data were used to calculate the position of the island and to find its true heading. It is interesting to note that the direction of "North" on the island changed nearly 45 degrees during a three-month period. This change of direction, however, was principally due to translation—a change in longitude—rather than absolute rotation of the island with respect to the earth (Fig. 3). This condition is accentuated, for navigational lines of longitude converge rapidly near the Pole.

The relative movement of the ice island and the

FIG. 4. A large salt ice hummock with dripping icicles, about a mile north of the edge of T-3.

FIG. 5. Pressure ridge in left foreground, open lead in center of picture. This is all salt ice, as contrasted with T-3, which is fresh ice.

surrounding salt sea ice pack was also measured. From a baseline established on the island, frequent triangulation readings to prominent ice-pack hummocks (Fig. 4) were made. Some of these targets were followed for several weeks before they became obscured or lost in the distance. In conjunction with these relatively large movements, delicate strain gauges were installed between different portions of the slat ice itself. These motions were of the order of 1/1000 inches, and a study of their variation should indicate the nature of internal ice stresses (Fig. 5). Also, as the motion of the ice is due principally to the wind forces, a series of anemometers was erected in order to measure the wind gradient over the ice.

Another interesting movement of the island was the tilt. The total amount was very small, about two minutes of angle over a two-month period. It was measured by means of an accurately calibrated bubble level. The trend is shown in Figure 6. It should be noted that the change is in one direction except under conditions of a N or NW wind.

In order to locate the campsite more accurately and for general mapping purposes, a transit traverse survey of the island was started. Elevations of the snow and ice surfaces at 300-foot intervals were obtained. Portions of the coastline have been plotted, as well as details of the ridges and valleys. This is a long-term project and will not be completed for some time. It was on one of these survey parties that the first signs of animal life were observed. Early in June 1952 a gull-like bird visited the island. It was tentatively identified as a jaeger. Evidences of polar bears and arctic foxes have been found, but the animals were not sighted.

One of the aims of the T-3 scientific program was a determination of the age and the possible origin of the island. Samples of the ice of the island afforded one source of such information (Fig. 7). Numerous ice samples were collected, and their density, salinity, and elastic properties were logged. Many of the samples were obtained with a coring auger, by means of which a cross section of ice several feet thick was obtained. In addition to the clear ice, several layers of fine, windblown dirt were found. Dirt was found about 4 inches below the surface at the bottom of holes having diameters of about ½ inch. These so-called ice wormholes were apparently formed by the heat absorbed by a small amount of dirt on the surface of the ice. By continually absorbing heat the layer of dirt gradually sank to a depth of about 4 inches. In a 22-foot core six distinct layers of dirt were found.

The existence of windblown dirt seems to confirm the belief that the ice islands were once in close proximity to land. It has been assumed that they are portions of a glacier which moved off the land into the ocean, finally breaking loose and

floating away. Lieutenant Colonel Fletcher, with other members of the scientific team, visited northern Ellesmere Island to investigate the ice shelf. The ice in the fiords of this area is quite similar to T-3. Disraeli Bay, Yelverton Bay, and McClintock Bay are possible sources of an island such as T-3. Another factor giving strength to this belief is the presence of large boulders on the edge of the ice island. These could have been deposited as the section of glacier passed between two mountains on its way to the sea.

A limited amount of oceanographic study has been carried out. A drag-type current meter was suspended through a hole in the pack ice, and currents with velocities between 0.06 and 0.4 knots were measured. The values obtained were a combination of the effect of motion of the ice plus water currents. In elaborating the data, the absolute motion of the island will be subtracted to get absolute current velocities.

Ocean depths were measured by sonic means. A tripartite array of geophones was used to measure both the ocean depth and the depth and possible tilt of sediments. During the first three months of the regular soundings the depths varied between 12,300 and 12,800 feet. During the course of these measurements several sea mounts were discovered rising from the bottom of the ocean. The shallowest depth recorded was about 9500 feet.

In order to obtain the elastic constants of the ice a seismic profile was shot to a distance of about 11,000 feet. An increase of longitudinal velocity from 10,500 feet/second to 12,500 feet/second was observed at a depth of 50 feet in the ice. The long-distance shots produced flexural waves, and from a measurement of their frequency an ice depth of about 150 feet was obtained. The value of gravity was read twice daily for a two-month period with a gravimeter, which gives relative values. As the island is in constant motion, the gravity meter readings were always oscillating about a point, the period of oscillation lying between 30 and 40 seconds.

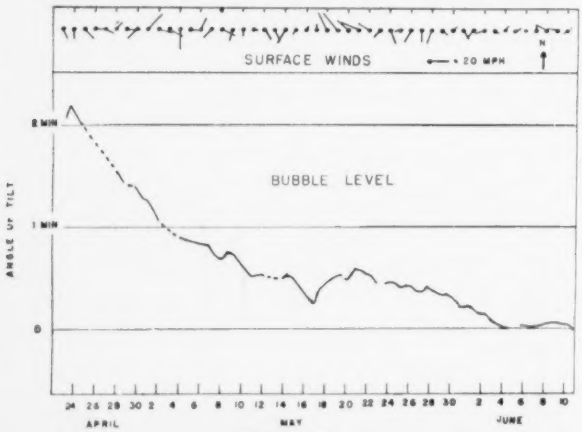


FIGURE 6.

FIG. 7. A. P. Crary cutting a section through the ice island with a chain saw, to determine its structure.

In addition to the regular work program, a series of special flights was arranged in May 1952. At a landing at the geographical North Pole, ocean soundings to a depth of 14,150 feet were obtained. Gravity was read, and samples of ice were collected for analysis. It is hoped that information on ice drift and ocean currents will be supplemented when bottles distributed around the general area are returned with a description of their final location and time and date of recovery.

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THE millipore filters, a new form of extremely porous matter, have been called "filters" because in their first and most obvious application of filtration they perform the function of separation of particulates from a dispersion medium. In this function of filtration they demonstrate a new uniformity and efficiency. They provide, for the first time, a means of quantitative concentration of bacteria dispersed in a liquid or gaseous medium to a virtual plane defined by the MF surface. It is perhaps useful to think of this phenomenon as illustrating a structure similar to a thin cross section of a honeycomb, the hexagonal openings of which are reduced to submicron dimensions. It might also be likened to a hypothetical submicron separatory screen made of wire of an infinitely small diameter, the openings being of a uniform size.

These comparisons are perhaps of some validity in that they illustrate the quantitative "surface screening" of the millipore filters. Some further insight into the actual nature of this new orientation of matter can be gained by empirical observations and measurements. It has been demonstrated that the MF HA type (hydrosol assay) filter will retain 0.3 μ (or greater) particles dispersed in water. Surface retention of particles from 0.5 μ is quantitative. The electron photomicrograph (Fig. 1) shows a sharp cutoff of particles at 0.3 μ. This photograph is representative of the filtrate achieved from filtration of a dispersion of fused silica particles of a size distribution from approximately 0.1 μ to 1.0 μ. As a control of production, quantitative surface retention of *Serratia marcescens* (0.5 μ) is established. It is significant that with this filter there has been no incidence of passage of this organism in more than 10,000 tests, each consisting of approximately 3,000,000 organisms over the effective filter area (9.6 cm^2). Figure 2 shows approximately 2400 colonies after 12 hours of incubation.

The proportion of structural filter material to voids may be readily established at approximately 82 per cent by volume voids and 18 per cent material. Laws of liquid flow in capillaries—e.g. Poiseuille's law—must assume some configuration of pores. No definitive index of the precise form of the interstices of this structure has yet been applied, but electron photomicrographs confirm the homogeneity of the surface indicated by retention properties. Assuming cylindrical capillaries perpendicular to the plane of the filter surface, the application of laws of liquid flow yields a pore size and number relationship through measurements of flow resistance. Particle retention in a water dispersion is a reasonable index of pore size and is perhaps more validly applicable because of the "surface screening effect." With a pore size assumed on the basis of the above reasoning, and the assumed configuration of cylindrical capillaries, it is arresting to note that, with the defined structure of 18 per cent substance, the pore or cell walls must approach monomolecular dimensions.

Instead of being composed of relatively large structural units such as cellulose fibers, as is the case in all conventional filter papers, the skeleton-like structures forming the pores of the millipore filters are of extremely minute "molecular" size. Relative to the pore dimensions, these structural elements are extremely small in the MF. If it were possible to make a filter paper (which it is not) that would have anywhere near the retention of the MFs (Fig. 3), such a paper would perforce have its unit of substance of a far greater diameter than the size of the voids or pores it would contain.

The true novelty of this new MF membrane consists in its construction of interstitial substance of molecular size. It is partly for this reason that the remarkable proportion of over 80 per cent voids is possible. Conventional filter mats composed of felted fibers depend largely on adsorption in the depth of the filter, since they are more or less random arrangements. For the sake of illustrative comparison, let us assume an ideal hypothetical arrangement of fibers of uniform cross section (Fig.

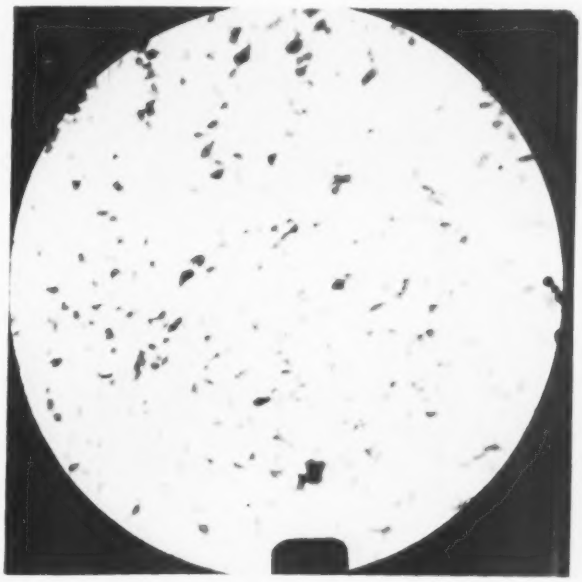

FIG. 1. Fused quartz particles. ×6100.

4), cylindrical in shape, and perpendicular to the filter surface.

For retention of spherical particulates of a size comparable to *S. marcescens,* assume the diameter of circle *P* to be 0.5 μ.

Area of fiber section $= \pi(AX)^2$.
Area of fiber sections defined by *AB, BC,* and $CA = \frac{\pi(AX)^2}{2}$.

Area of triangle $ABC = \sqrt{3}(AX)^2$.
Area of void section between fibers $= (AX)^2\sqrt{3} - \frac{\pi(AX)^2}{2}$.

Volume of void section $= h\left[(AX)^2\sqrt{3} - \frac{\pi(AX)^2}{2}\right]$.

Volume of fiber structure $= h\left[\frac{\pi(AX)^2}{2}\right]$.

Ratio of voids to fiber volume $= \frac{h\left[(AX)^2\sqrt{3} - \frac{\pi(AX)^2}{2}\right]}{h\left[\frac{\pi(AX)^2}{2}\right]}$.

Therefore this structure would be 91 per cent fiber by volume and 9 per cent voids. The diameter of the fibers would be 1.5 μ, which is smaller than the practical minimum of any fiber, natural or synthetic.

This hypothetical orientation of fibers bears no true relationship to actual filters composed of fibrous elements. It is, however, of some value in a comparison of the function of quantitative surface retention of the MF and its efficiency in terms of resistance to flow, as against the properties of adsorption and entrapment that contribute to the efficiency of fibrous filters.

The significance of this new tool in bacteriology is, however, only partially described in terms of quantitative "surface screening" of particles sharply defined as to size in the submicron range. Bacterial cells retained from a dispersion on the two-dimensional filter surface find themselves in a novel and unique environment. They are, so to speak, perched on pinnacles defined by the millions of capillaries perpendicular to the plane of the filter surface. Nutrient is supplied to these isolated cells independently by the contiguous capillaries and utilized by adsorption more or less according to nutritional requirements. A large and relatively uniform amount of surface of these bacterial cells is exposed to the atmosphere over the filter, which may be nicely controlled. This factor is undoubtedly of significance in the extremely fast growth rates observed—as, for example, bacteria requiring large amounts of oxygen. The process of filtration will isolate and remove bacteria from inhibiting materials, such as bacteriophage, that might be present in the original sample or dispersion. Metabolic by-products of the bacteria seem to be adsorbed to a very large extent by the tremendous proportion of surface exposed by the filter material. Cross-

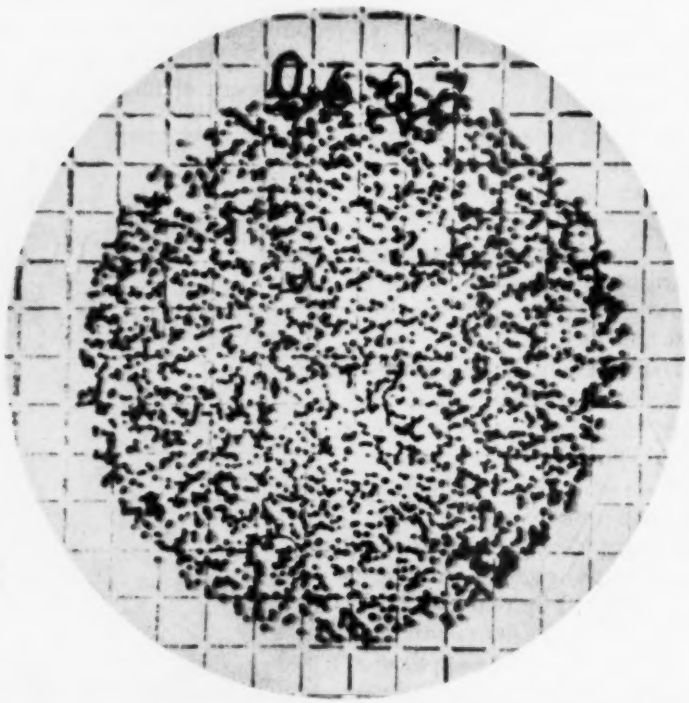

FIG. 2. Approximately 2400 colonies on the MF surface after 12 hours' incubation.

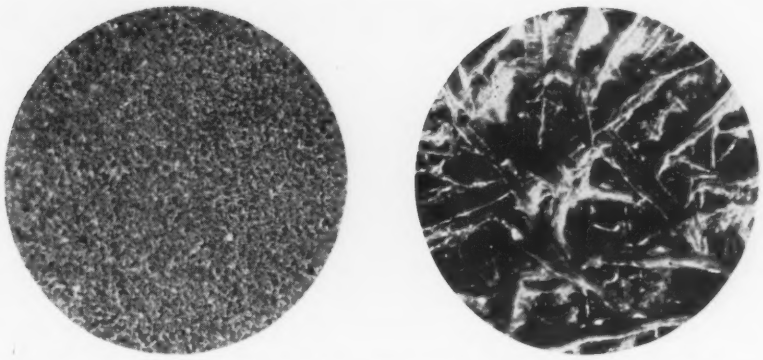

FIG. 3. Photomicrographs (approx. × 100) showing millipore filter surface (left) and dense filter paper surface (right).

diffusion, lateral growth, and interaction between bacterial cells so isolated and cultured are minimized by the nature of the structure of the filter material.

The many factors, not well understood, that contribute to the extremely rapid and uniform growth of bacteria on the filter surface, coupled with the ease of microscopic examination at early growth stages (the bacterial cells being in a virtual plane), have resulted in the development of techniques for much earlier and more positive identification of specific microorganisms. Obviously, this fact has very broad implications in the field of bacteriology, particularly from the standpoint of sanitary control. Outstanding work has been carried on by the U. S. Public Health Service Environmental Health Center on the adaptation of the MF technique to the bacteriological examination of water.*

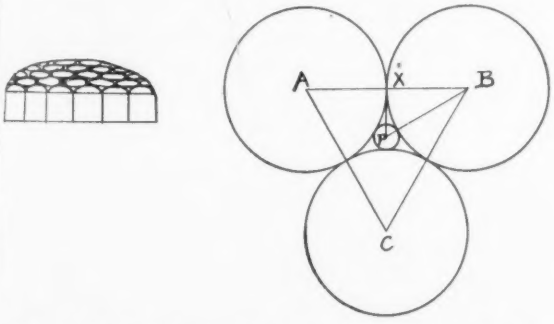

FIG. 4. Left: Schematic view of cross section of hypothetical fiber filter; right: Large circles with centers *A, B,* and *C* represent cross sections of fibers. Small circle with center *P* represents defined pore.

To summarize some of the conclusions that may be drawn from a study of the use of the MF in sanitary water control, the millipore filters:

1) Provide a method for the accurate coliform analysis of water within 18–20 hours instead of the usual 4–5 days. They also provide for a direct count of coliform organisms instead of the "most probable number" (MPN solid media).

2) Facilitate a rapid and more sensitive identification of pathogens in water.

3) Increase the size, and therefore the reliability, of samples by a factor governed solely by bacterial concentrations.

4) Increase the number of colonies that may be counted from a single dilution by thirty to fifty times.

5) Permit at any time during the growth cycle the transfer of growing organisms from one or more enrichment media to special differential media.

6) Provide, for the first time, a convenient method of bacterial sampling in the field.

7) Reduce cost of each analysis by as much as $1.50.

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* This work is briefly outlined in a booklet describing millipore filters, *Characteristics and Uses of the MF Millipore Filters,* which may be obtained from Lovell Chemical Company, Watertown 72, Mass. Further details of the techniques may be learned by means of the bibliography in the booklet.

† Figure 1 used by permission of Melvin First, Harvard School of Public Health, and Richard Charles, Massachusetts Institute of Technology; Figures 2 and 3 used by permission of Alexander Goetz, California Institute of Technology.

THE SOLAR ECLIPSE OF FEBRUARY 25, 1952

A GROUP of fourteen people, eleven from the scientific staff of the Naval Research Laboratory and three from the High Altitude Observatory under contract to NRL, traveled to Khartoum, Sudan, to perform six experiments during the total solar eclipse of February 25, 1952. Thanks to good weather and painstaking preparation, all experiments were carried out successfully and will be reported in various scientific journals when the data have been analyzed.

The eleven from NRL were John P. Hagen, W. E. Berg, F. T. Haddock, Carl A. Beck, D. J. Lovell, J. E. Gibson, Donald White, R. M. Sloanaker, R. J. McEwan, D. S. Hawkins, and E. O. Hulburt; the High Altitude Observatory was represented by J. W. Evans, R. H. Lee, and R. H. Cooper.

The experiments had been planned more than two years ago, and in June 1951 Commander Berg and Dr. Hagen studied several possible locations, choosing Khartoum because of the excellent possibility of good weather and the convenient living and working conditions. A site was selected in the desert about two miles from the city and within a mile of the center line of totality. Rooms were reserved for the party in the Grand Hotel, on the left bank of the Blue Nile.

In December 1951, about seventy tons of equipment were shipped on a freighter to Port Sudan and thence by rail to Khartoum. The eclipse party, all of whom had had previous experience in eclipses, arrived by air on January 14 and, under the direction of Dr. Hagen, immediately set about installing the equipment. Practically all the apparatus had been designed for use in the field and had been thoroughly tested in the field or during eclipses. As a matter of fact, an eclipse operation is much smaller and less complicated than many other kinds of field experiments, and the few setbacks were normal in work that was essentially routine.

We were up each morning by 5:30, had breakfast, and were at the site at 7:00 o'clock, for this was the best time of day. Work continued until noon, and after lunch and rest at the hotel, it was resumed from 3:00 to 6:00, with some groups working every night. A hot spell set in, with midday temperatures above 100° F. and night temperatures above 80°. There were several mild attacks of "colly-wobbles" (dysentery). Dr. Evans fell off his spectroscope one night and broke his ankle, but thanks to the excellent attention he received from the British doctors, he was out again after four days in the hospital, at first in a chair and soon on crutches.

Our two jeeps and the weapons carrier provided essential transportation, the photographic trailer with its cooling system made impossible photographic work possible, and the truck-mounted 25-kw generator ran for seven weeks without skipping a beat. Concrete foundations were poured; the radio telescopes, the corona telescope, the Mitchell cameras, and the five spectrographs were erected on various mounts (Fig. 1).

The 10-centimeter and 8-millimeter radio wave receivers (Figs. 2 and 3) were provided with automatic recording and sensitivity calibrating devices. Both were truck-mounted and, after being put in position, were provided with cement-based supports. The 10-centimeter receiver, with its 6-foot diameter parabolic mirror, recorded the solar emissions in this wavelength and gave information about the density and temperature of the solar

FIG. 1. NRL equipment on site southeast of Khartoum.

FIG. 2. Ten-centimeter radio telescope.

atmosphere in which the emissions originate; these are about 10,000–50,000 km above the photosphere in the upper chromosphere and lower corona. The 8-millimeter receiver was arranged with a double astigmatic mounting of two cylindrical mirrors to focus on a region about 8 minutes of arc in width of the path of the moon across the sun. It determined the intensity at this wavelength, which was emitted probably from middle chromospheric regions 5,000–10,000 km above the photosphere, just above the main flash spectrum levels. The equipment of the High Altitude Observatory consisted of three spectrographs—ultraviolet, visible, and infrared—carried in a single mount. They photographed a series of flash spectra with very accurate positioning and timing, in order to ascertain the composition, density, and temperature of chromospheric levels. With two cine-spectrographs of different dispersions, spectra were taken at the rate of one per second of the crescent edge of the sun near second and third contacts, to determine the darkening of the sun near the limb and to give information on the temperature of the photosphere and inner chromosphere. In combination these experiments constituted a powerful and concerted attack on the problems of the solar surface and the solar atmosphere up to several thousand kilometers above the surface.

Since no eclipse work can be said to be complete without a picture of the solar corona, there was the beautiful 18-foot corona telescope (Fig. 4), designed by I. C. Gardner and lent to us by the National Bureau of Standards. This had been adjusted especially for the eclipse, and a standardizing scale and polarizers had been added in order to determine the amount of polarization and distribution of energy in various parts of the corona. There were two long-focus Mitchell cameras, provided with accurate time marks (Fig. 4), for taking slow-motion pictures of the sun during the progress of the eclipse, one in black and white, and one in color.

More than 140 astronomers from twelve nations had gathered at Khartoum, and most of them were living at the Grand Hotel. It was perhaps the greatest assembly of eclipse talent that had ever been brought together. There was opportunity for discussion in the evenings, and several symposia were held at the university, with talks given by astronomers from different nations. There was, however, practically no chance to visit the several eclipse sites of the other parties, which were scat-

tered all over the city, because everyone was too busy. We were interested to discover that, with one exception, there was no exact duplication of our experiments by others. It was almost inevitable that someone else would plan to photograph the corona, however, and Professor Madwar, of Helwan Observatory, Egypt, obtained a very beautiful picture.

On Sunday, February 10, a cold front from the north brought the hot spell to an end. A strong breeze stirred the sand up into a haze, reducing visibility to less than a mile, but in the next few days the breeze and the sand haze subsided, leaving the air very clear. The humidity was quite low at all times. A measurement showed that the vertical transmission for light through the entire atmosphere was about 85 per cent—not much less than the 88 per cent value for ideally pure air. This condition persisted for more than a week, with practically no clouds in the sky. At night the zodiacal light was a familiar phenomenon, and the Southern Cross appeared low above the southern horizon. The midday temperature was rarely above 95° F., and the night temperature was 70°–80°, which was very pleasant indeed.

All equipment was brought into working condition and good adjustment. Full-scale rehearsals were carried out once a day at eclipse time (11:12 A. M.) and oftener when necessary. The Minister of Public Works of Khartoum offered to lend us a spare generator and to operate it during the day of the eclipse. This offer we gratefully accepted, and, although the generator was not needed, its busy presence in an adjoining field (of sand), ready to be switched in at a moment's notice, gave us a reassuring feeling of confidence. In fact, throughout our stay the British and Sudanese authorities were always ready to help us in every way possible. For example, during the three hours of the eclipse, a police detail stopped all traffic—automobiles, donkeys, and camels—along the road passing near the site, as well as the trains on the track about four hundred yards distant.

On Friday, February 22, a strong north breeze blew all day, covering everything with sand and raising a thick haze of dust. On Saturday the breeze subsided, and on Sunday the air started to clear again; the measured vertical light transmission of the atmosphere was 71 per cent. Monday, eclipse day, dawned clear and cloudless, with a gentle breeze; the atmospheric transmission at 9 A. M. was 76 per cent, which was very good—good enough for most eclipse observations, and better

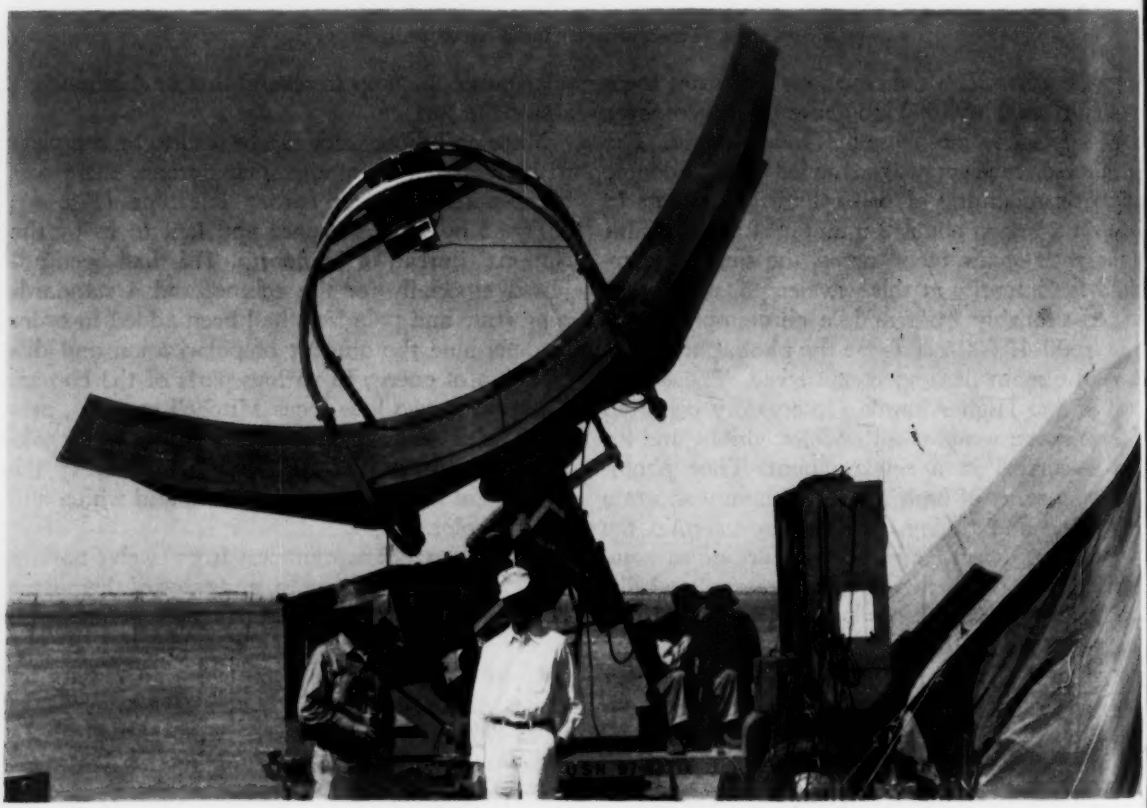

FIG. 3. Eight-millimeter radio telescope.

than many eclipse observers have experienced. We were out at 6 A. M., with generator going and everyone engaged in last-minute preparations. The eclipse took place on schedule, and the contacts occurred within a second of their predicted times (as well as could be inferred from casual observations—the contact times will be known with considerable exactness when the moving picture data are worked out).

First contact was at 9:45 A. M. As the first phase of the eclipse progressed, the daylight became dimmer, there was less breeze, and all nature seemed to be enveloped in an expectant hush presaging the surprisingly glory of totality. At 11: 12 A. M. the face of the sun was blotted out, and the corona flashed into view (Fig. 5). Mercury and several brighter stars appeared, and a red hydrogen prominence was visible on the right-hand side of the sun. Everything was very quiet, except for a few clicks when plate holders were changed. None of our operations made much noise. Those whose duties permitted watched the corona and the eclipse scene. It was fairly light, and one could easily read the second hand on a watch at all times. For this eclipse, totality lasted only 3 minutes and 9 seconds; a longer eclipse is of course darker because the shadow of the moon is larger. There were no shadow bands at our site at either second or third contacts. After totality those groups whose experiments were completed could relax. The two radio wave groups continued their measurements through the final phase until the end of the eclipse at 12:38 P. M.

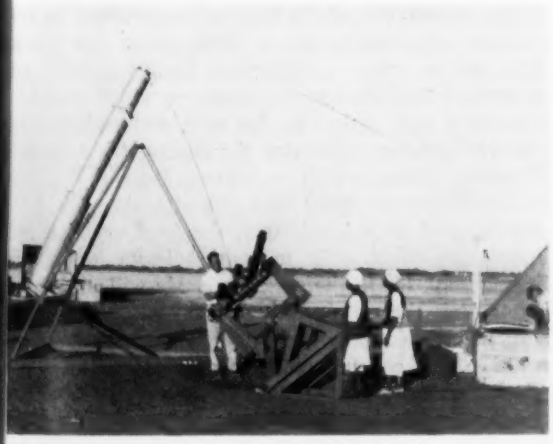

FIG. 4. Gardner corona telescope and Mitchell cameras.

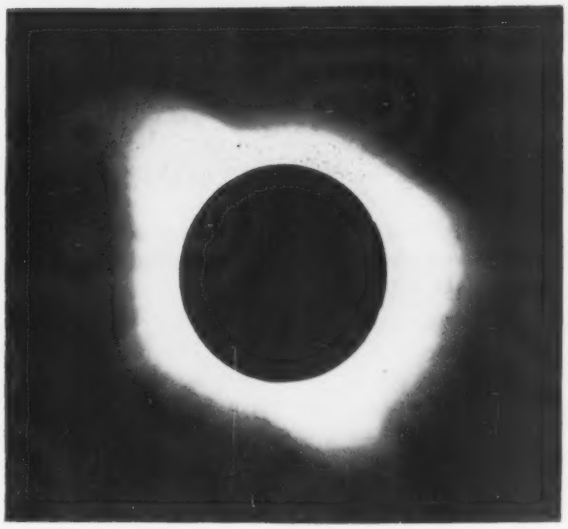

FIG. 5. Solar corona of February 25, 1952, taken by the Gardner telescope with a 10-second exposure.

There followed the usual calibration, standardizations, and processing of films and plates. Not until another day had passed could a final reckoning be made and the conclusion reached that all experiments had been carried out according to plan and all data successfully recorded.

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BOOK REVIEWS

MAN'S MOST NUMEROUS ENEMIES

Insects, The Yearbook of Agriculture. xviii + 780 pp. 72 colored plates with text. $2.50. GPO, Washington, D. C. 1952.

THIS volume is a veritable Who's Who among the Insects, of which over 82,000 of the 900,000 known species live in the United States. From day to day, the authors explain, other unwanted insect immigrants gain entrance, despite the constant inspection at all ports of entry, whether by boat, train, airplane, auto, or by air currents or pedestrians.

Not all the 82,000 are found in a single garden or even in one state. The number listed in any state varies with the diligence of the entomological census takers. Within the limits of 780 pages only the most noted or most notorious species could possibly be included, only those that are most useful or destructive, or most often observed or inquired about. And from this list of the pests that most seriously attack plants, animals, and man and his household, 72 are singled out for special treatment in more detail, with colored plates to illustrate the various stages of these pests.

When a farmer notices for the first time some pest on his cows, apple trees, or corn he is likely to inquire how it got there and where it came from. That whole problem is laid bare in the book. Insects are the most expert hitchhikers and fellow-travelers on earth. On every ship entering the country there are insect stowaways, such as houseflies, roaches, lice, mosquitoes, and dozens of other species, not only at large in the cabins and all parts of the ship but in the freight, the baggage and clothes of passengers, and, still more serious, often in material which travelers conceal in the hope it will escape detection by quarantine officials. Along our Canadian and Mexican boundaries, insects may hop, fly, or crawl across by night or day. On every airplane are pests that would gain entrance unless stopped at quarantine.

Air currents and storms bring in insects from the islands of the Caribbean, from Mexico, Central and South America, and Canada. Even weak-flying insects have been caught by airplanes at 13,000 feet altitude or higher, carried by air currents. Over 2000 kinds of insects have been intercepted as hitchhikers in airplanes. Migratory birds may carry pests attached to their skin or feathers. Ships' ballast is a favorite vehicle for bugs, often in seeds, roots, or stems of their host plants. Fruits and vegetables brought in as food by the crews or passengers are always to be suspected.

But there are thousands of pests that have not yet crossed our frontiers, largely by reason of the alertness of horticultural inspectors at quarantine. By long experience they have learned the tricks of insect travelers. It is comforting to observe how strictly this inspection is applied at all ports by land or sea. For the exclusion of hundreds of known pests we have the quarantine service to thank.

Just 100 years ago Townsend Glover was assigned to the Bureau of Agriculture, then a branch of the Patent Office, "to collect information on insects, seeds and fruits." From that small beginning economic entomology, in answer to urgent demand, has grown into a large army of trained scientists engaged in a battle with insect pests to minimize their destructive raids on plants and animals. The present insect yearbook is the boiled-down essence of the vast store of knowledge accumulated on entomological lore. In the language of the street, it's a whodunit (and what to do about it), planned by a committee of eleven and written by more than 100 specialists in various phases of the subject.

Throughout the whole field of entomology in this yearbook, the information is authoritative and specifically tied to present conditions, facing squarely the gauge of battle of man *vs.* insects, in which man risks losing the fight unless by his wits and technical ingenuity he can outmaneuver the enemy. It's a struggle of science against numbers. The reader will find help in identifying the pests that are attacking his crops, something of their life history, the farm practices and insecticides effective in preventing losses, and where he may look for further assistance. He will understand better how the omnipresence of insects in the field, barn, house, clothing, and on his livestock makes imperative the keenest interest in developing new methods of warfare, why 10,000 or more chemicals are tested yearly for destroying pests, why over 2000 plants have been analyzed in the search for new pesticides, why chemists are compounding new substances in the hope of developing remedies lethal to insects that will at the same time be harmless to man and livestock.

The reader will learn how the tide of battle shifts from day to day; how flies, mosquitoes, and other insects may become resistant to remedies which before had been instantly lethal, necessitating the production of still more powerful compounds; how changes in farm practices and timing of the application of highly toxic pesticides may kill injurious insects while sparing honeybees; and the beneficial species of parasites and predators. Hundreds of successful battles against specific pests are described, including the dramatic story of the extermination of the Mediterranean fruit fly in Florida.

Over 5000 aeroplanes are engaged in raining down poisonous sprays and dusts on whole countrysides in

the effort to combat the depredations of flies, mosquitoes, green bugs, and grasshoppers. Skill, industry, and imagination are cooperating in the search for still more toxic compounds, fatal to pests and harmless to man, of which pyrethrum and rotenone are shining examples.

The reader will be reminded not only of the ubiquity of pests, and that their chief activities are eating and multiplying 24 hours a day, but also of the necessity for nationwide spraying of gardens, fields, livestock, stables, and kitchens. Pests feed not only on the roots, stems, leaves, and kernels of wheat but also follow the grain to the elevator and to the flour mill. Everything we eat or wear has been sprayed one or more times.

The possible cumulative effect of eating fruits and vegetables sprayed with toxic chemicals, or of drinking milk from cows dusted with DDT to kill horn flies, or from wearing clothes that have been insect-proofed is exhaustively considered. Hearings were held for nine months, during which 9000 pages of testimony were recorded to serve as guidance for entomologists, manufacturers, and private users of toxic pesticides.

Although the housefly may lay 21 batches of eggs in her five months of life, completing a generation every two weeks; the termite queen may lay 6000 eggs per day; more than 200 species of insects attack apples, and similar lists of pests feed on other crops; and grasshoppers may deposit 25 clusters of eggs per square yard of soil; and so on through the long list of insect enemies—we are assured that there is no reason to be overpessimistic. The betting odds are in favor of man. Flies and mosquitoes are losing the fight. Pests may become tougher to handle, but correspondingly more powerful chemicals await their raids, and more and better parasitic insects are being marshaled to cooperate with the farmer.

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THE FLOWERLESS PLANTS

Ferns of Michigan. Cecil Billington. vii + 240 pp. Illus. $5.00. Cranbrook Institute of Science, Bloomfield Hills, Mich. 1952.

AMONG numerous fern floras of recent years this new book from the Cranbrook Institute of Science ranks high. Included are the Michigan members of the families of true ferns and adder's-tongues, as well as their so-called allies, the horsetails and scouring rushes, the club mosses, quillworts, and selaginellas. Billington's death early in 1950 occurred before the book was finished, and Dale Hagenah, Stanley Cain, M. T. Hall, and others contributed to the completed work. It contains 23 genera, 80 species, 37 varieties, and 39 forms, named and arranged in accordance with Fernald's treatment in *Gray's Manual* (8th ed.). A detailed introduction adds considerably to the worth of the book, with paragraphs of general interest on the origin, reproduction, economic value, culture, and collection of ferns. The illustrations, including 81 excellent line drawings, 17 photographs, and a pictorial glossary, with the help of the keys provided, make it easy to use. The distribution maps that accompany the species are based upon actual specimens, but they clearly show further opportunity for more field work in Michigan. Even some of the abundant species have still not been collected in the middle countries of the Lower Peninsula, and the exact borders of ranges of rarer species are still far from known. Some of the Farwell collections of over sixty years ago provide an odd mystery, and careful further attention should be given to them. A number of species, *Equisetum telmateia, Lycopodium alpinum, Woodsia obtusa, Polystichum acrostichoides, Dennstaedtia punctilobula, Asplenium montanum, A. cryptolepis,* and *Dryopteris hexagonoptera,* were all presumably found by Billington in the Keweenaw Peninsula as "disjuncts," but none have been found in that well-known area since. A number of taxonomic problems should be reinvestigated, especially in the groups of *Equisetum hyemale, Botrychium lunaria, Lycopodium complanatum, Cystopteris fragilis,* and of true *Dryopteris.* The study of hybrid populations of Michigan pteridophytes is practically untouched.

Ferns of Michigan will serve the " layman and nature lover" most adequately, as the author intended. I believe, too, that from the botanical standpoint, this volume, in organizing for the first time the information for this state, will serve as an impetus to investigations of a number of interesting problems in this fern flora.

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THE HEAVENS CONSIDERED

Basic Astronomy. Peter van de Kamp. xv + 400 pp. Illus. $3.75. Random House, New York. 1952.

THIS reasonably priced book is well written and reads easily. Especially is the material in the chapters dealing with the observational aspects of our galaxy and of extragalactic nebulae excellently represented.

In his preface the author states that one of his aims is to attempt to make the reader aware of the methods employed by the astronomer, and of the development of his ideas and knowledge. It seems to me that he has succeeded in doing this; the historical approach is also apparent in the insertion of the years of birth and death behind the name of each astronomer.

A minor critism is that it is not quite clear for whom the book is intended. It sometimes seems as if the author has written down his lectures verbatim (for freshmen?), but points that can pass in a lecture often should be explained more fully in a book, and vice versa. If the book is meant for freshmen expecting to go into science, it seems strange, for instance, to find an explanation of π (p. 156). In that case an occasional equation might also have been used. If, on the other

hand, the book is mainly intended to familiarize arts students or the average layman with astronomy, it might have been worth while occasionally to insert fuller explanations. It will, for instance, not be clear to such readers what is meant by Euclidean geometry (p. 151).

The book consists of four parts entitled, respectively, A Survey of the Solar System, The Mechanics of Stars and Planets, The Physical-Chemical Properties of Sun and Stars, and The Milky Way System and Beyond.

Pictorial Astronomy. Dinsmore Alter and Clarence H. Cleminshaw. 296 pp. Illus. $4.50. Crowell, New York. 1952.

IT IS very seldom that one can agree wholeheartedly with the description of a book given on its cover, but in the case of this attractive volume the passages "A fascinating guide to a fascinating subject," "It is clearly and entertainingly written, filled with most interesting facts, and lavishly illustrated with photographs and diagrams," and "For anyone who feels the spell of the heavens . . . *Pictorial Astronomy* is just about perfect" give, in my opinion, a correct impression of this excellently written and produced book. Moreover, the volume is reasonably priced, and one must congratulate authors and publisher on the production of this work.

The authors state in their preface that the material of the book has been chosen principally with the layman in mind, and they have succeeded in producing a really first-class introduction to astronomy for the nonscientist.

The seven main sections deal successively with the sun, the earth (an enthralling chapter discusses the calendar, its history, and possible reform), the moon, eclipses, the planets, comets and meteors, and finally stars and nebulae. The level of treatmnt is everywhere kept simple but without overdoing the simplification. It is refreshing to find a book where the reader is treated as a thinking adult, be it without technical knowledge, and not, as is all too often done these days, as a child of four.

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ARCHAEOLOGY AND RELATED SUBJECTS

Prelude to History. Adrian Coates. xviii + 289 pp. Illus. $4.75. Philosophical Library, New York (printed in Great Britain). 1952.

Prehistoric Europe. The Economic Basis. J. G. D. Clark. xix + 16 plates + 349 pp.; text illustrations. $12.00. Philosophical Library, New York (printed in Great Britain). 1952.

ON THE basis of the difference in price between these two books, both recently published in New York by the Philosophical Library, the intelligent general reader will doubtless calculate that Adrian Coates' *Prelude to History* at $4.75 is a bargain, and accordingly he will purchase it, rather than Grahame Clark's *Prehistoric Europe* at $12.00. In the present reviewer's opinion, however, this would be a grave error of judgment. For *Prehistoric Europe* constitutes a major contribution to the literature in the field of prehistoric archaeology, whereas *Prelude to History* can only be regarded as a semipopular statement of the views of an intelligent and keenly interested layman who has tried to follow recent developments in Paleolithic archaeology and related subjects. In other words, Clark's book is written for specialists and advanced students in the field, whereas Mr. Coates, himself a nonprofessional archaeologist, has made a serious effort to present a summary account of man's cultural development during Old Stone Age, or Paleolithic, times.

Prelude to History is certainly *not* a textbook, and it makes no pretense on this score. As the author himself states in his preface,

> It is written for people like myself who, without being specialists in any particular discipline, are curious about all sorts of things, about the origin of mankind, the meaning of history, the theories of Freud and Frazer, the significance of race, as well as the industries and art of our remote paleolithic predecessors, and who wonder how all these different topics fit together to make a coherent whole.

But the book admittedly is not merely a digest of the facts and theories recorded and propounded by other authors, since Mr. Coates puts forward certain ideas that should be of interest to all students of culture history. In discussing the scope, method, and aims of prehistoric archaeology, he differentiates between those whose major interest is in the nondocumentary remains of the past and the archaeologist-historian. This section of the book should appeal to a wider group of readers than those who will use the work as a whole as an elementary introduction to Paleolithic archaeology.

Perhaps the greatest shortcoming of *Prelude to History* is the failure of the author to relate the varied assortments of Paleolithic cultures which he describes to the fairly well-established regional chronologies that have been worked out for the Pleistocene. Indeed, even such fundamental and basic archaeological concepts as stratigraphy are scarcely considered at all, and no attempt is made to tie in the section dealing with the framework of terrestrial change with those chapters in which the Paleolithic cultures themselves are described. Nor is the evidence for the sequence of the latter presented in a single instance. Another shortcoming of the book that is very difficult to comprehend is the inclusion of a 40-page chapter on racial classification. Not only does this survey of existing peoples have but a very remote bearing on the main subject matter, but also my colleagues in the field of physical anthropology inform me that Coates' seven physiographic groups imply a degree of oversimplification that is not generally accepted by workers in the field. Lack of space prevents making further comments on *Prelude to History*, which, if not to be regarded as authoritative, is a good thought-provoking book for amateurs.

Professor Clark's *Prehistoric Europe*, on the other hand, is a scholarly treatise

. . . concerned with the ways in which early man, in competition with other forms of life, maintained himself on European soil since the end of the Pleistocene Ice Age, and with how he managed not merely to survive but to raise his standards from those of savages to those of peasants ready to support the full weight of urban civilization.

It is a work of the first order of importance that will appeal to geographers, ecologists, and historians, as well as to prehistoric archaeologists. Using the European cultures of the Late Glacial Period as the point of departure, the author deals with such aspects of economic life in prehistoric Europe as hunting, fishing, and plant-gathering (food-collecting); forest clearance and farming (food-producing); the construction of houses and settlements; stone, bronze, iron, and other technologies; trade; travel and transport—actually only a small proportion of the available evidence. Throughout, his aim is to demonstrate how the relationships between human society, on the one hand, and the natural environment, on the other, were always reciprocal: human communities can no more be studied apart from the great plant and animal eco-system than can the latter be divorced from a consideration of the influence of human agents, which remain essentially animal in nature. This study is based primarily on archaeological evidence, but early historical sources, as well as those folk cultures that still exist in certain marginal parts of Europe, have been considered as well.

By his penetrating analysis of the factors involved in determining the development of successively more highly integrated economies, Clark has set new standards for archaeologists to measure by. In so doing he has placed himself solidly in the debt of his colleagues interested in the prehistory and protohistory of Europe, as well as in those allied fields of the natural sciences concerned with problems of an ecological nature. Because of the numerous illustrations, this is a comparatively expensive book, but when one scrutinizes the text closely, it will become apparent to the serious student of archaeology that it is one he cannot afford to be without.

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LOOK TO THE SEA

Seaweeds and Their Uses. V. J. Chapman. xiv + 287 pp. + 20 plates. $6.00. Pitman, New York. 1952.

THE author is professor of botany at University College, Auckland, New Zealand. He has written a book on seaweeds which is meant to augment and to modernize the treatment of this subject by Sauvageau (1920) and by Tressler (1923), but the volume was compiled before the second edition of Tressler appeared in 1951. The treatment of the subject matter may be described as semipopular, and the book has been written with the general reader in mind, rather than the specialist. Emphasis has been placed on the historical aspects of the subject. Thus the rise and decline of the manufacture of potash and iodine from kelps and the production of organic extracts from various species are described as representing the three epochs in the industry.

The book is divided into nine chapters. The first describes the occurrence and distribution throughout the world. Drawings illustrate the thallus of the most important species, and the common names are listed. This section could well have been expanded to make the volume useful for popular identification. The second chapter is mainly historical and is neither complete nor systematic, but it contains many interesting facts. The third chapter is on the kelp industry and iodine. Confusion in the use of the term "kelp" is clarified to distinguish three usages—the old to designate the burnt ash of seaweed, the common to designate any large seaweed, and the American to designate the large brown forms. The enormous proportions of the industry for the production of alkaline ash in the early nineteenth century are substantiated by facts for various countries, and methods are described for the manufacture of potash and iodine. The fourth chapter extends this treatment to the American Pacific coast and describes the destructive distillation and fermentation of seaweeds, with a minimum of basic chemistry.

The production of commercial agar-agar is outlined in Chapter 5. Various red algae are used in this process, especially *Gracilaria* (Japan), *Gelidium* (USA), *Gigartina* (Great Britain), *Pterocladia* (New Zealand), *Suhria* (South Africa), *Ahnfeldtia* (Russia), *Eucheuma* (Japan, Ceylon), and several others. There is a brief treatment of the chemistry of agar and its uses.

Two chapters on seaweed as food and as fertilizer follow. This treatment is probably the most complete of the book, and interesting comparisons, based on analytical figures, are made with other fertilizers. Modern nutritional aspects of seaweeds are treated briefly, mainly because of the scanty scientific literature available.

The eighth chapter deals with the alginate industry and the use of seaweeds in medicine. The final chapter presents a picture of the world's supplies and of the methods in use for purposes of survey. Some statistics of amounts harvested are listed, and the lack of knowledge on regeneration is emphasized.

The book is replete with accounts of pertinent incidents and quotations, which greatly increase its interest for all readers. The picture presented is on a large canvas with the world as background. An addendum brings the subject matter up to 1949. The bibliography is remarkably complete and occupies twenty pages. As an interesting semipopular treatment of seaweeds the book is of real value and has a definite place; it is so recommended.

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COMPREHENSIVE BIBLIOGRAPHY

Physiology of the Circulation of the Brain. An Annotated Bibliography, 1938–1948. Compiled by Roman Kenk and Mabel L. Nall. 437 pp. $4.50. Physiological Reviews, Vol. 32, Supplement No. 1 (1952), Baltimore, Maryland.

THE problem of the cerebral circulation has long been recognized as one of the most complex and difficult in the realm of physiology. Nevertheless, within recent years increased attention has been directed to studies on the physiology of the blood flow through the brain. Among the factors that have operated to stimulate this increased research activity none has been more potent than the world military situation. World War II and the subsequent armaments race, during which new and more effective weapons have been developed and used, have focused attention on man's capacity to react to new physiological situations and on his reaction to new and more terrible forms of injury.

Taking cognizance of this situation, the Division of Biological Sciences of the Office of Naval Research, early in 1947, requested the Library of Congress through its Division of Technical Information to undertake a thorough bibliographical survey of published research on the physiology of the circulation through the brain. The purpose of this survey was to provide a base line for planning future research. So that the project should not become too large and unwieldy, the survey was limited to a ten-year period. These ten years, however, included the period of World War II, during which the free interchange of information was practically impossible. Nevertheless, considerable work went on in laboratories of the warring and occupied countries, and much of it was published, although the journals and books were not available for worldwide circulation. Immediately after the cessation of hostilities, much of this literature began to trickle from warehouses and other storage places into libraries, and thus to enter the main stream of scientific information again. So vast was the backlog, however, and so widely was it dispersed through numerous journals in many languages, that no one person could hope to catch up with all of the literature he might have missed. Furthermore, just keeping up with the current flood of new papers and reports is a task that all but overwhelms the worker, be he specialist or generalist.

It is to this situation, limited to a special field of research and to a special group of problems in this field, that the bibliography here reviewed makes a major contribution. The compilers have searched, examined, screened, and annotated a large segment of the world's published literature on the subject of the cerebral circulation. The notes are descriptive, not critical, criticism being properly left to the experts in the field. Through the use of the resources of the Library of Congress, the Armed Forces Medical Library, the New York Public Library, the Library of the New York Academy of Medicine, the Welch Medical Library, and many others, practically every paper published here and abroad has been located and listed. The persistence and thoroughness of the coverage are indicated by the fact that of more than 2000 papers included in this monumental list, only about 20 were not personally examined by the compilers.

The papers and monographs are arranged alphabetically by authors, and a detailed subject index of 54 pages provides the key to this treasure house. All titles are in the original language, followed by a translation, and Russian titles are transliterated.

As mentioned above, only the literature on the physiology of the cerebral circulation has been included. The following broad categories were surveyed:

a) Anatomy and development of the cerebral vascular system.
b) Blood, cerebral blood flow, and its regulation.
c) Brain metabolism in relation to circulation.
d) Alteration of the cerebral circulation by physical and chemical agents.
e) Relations between cerebral circulation and brain activity.

Papers dealing strictly with pathology or with clinical data have generally been excluded.

The Office of Naval Research, the Library of Congress, and the American Physiological Society all deserve great credit for having made this splendid bibliographical tool possible. As for the diligent compilers, they have constructed their own enduring monument. Critics will look hard and long before finding any flaws in their meticulous work.

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BRIEFLY REVIEWED

Quantum Theory of Matter. John C. Slater. 528 pp. $7.50. McGraw-Hill, New York. 1951.

ONE seldom finds between the covers of a single volume such a comprehensive treatment of the theory of matter and its properties which also includes the development of quantum theory. Professor Slater, in his characteristic fashion, has prepared a very readable book at a level of difficulty not beyond the reach of the intermediate student or the experimentalist. His approach is most refreshing in that the basic aspects of quantum theory are developed from a historical point of view. Thus the author clearly points out how the development of the discipline of quantum mechanics, together with the increasing knowledge of the nature of matter, is the result of organic and historic growth. Treated in this manner, quantum theory makes rather exciting reading. One obtains a perspective that too often is lacking in the usual presentation. The author is gifted in the forceful use of analogy, and frequent and apt use of this tool adds to the clarity of the presentation.

After following the development of the theory, the reader is carried on to application of the theory to various properties of matter. Thus, from the theory

and its application to atomic structure one is led on to the structure of molecules, ionic and covalent binding, and the band theory of solids. Besides treating structure per se, corollary properties are also treated—in particular, electrical and magnetic properties.

The author has attempted to avoid as much as possible excessive mathematical complexity and has included a rather complete set of appendices which cover briefly, but on the whole quite adequately, a more advanced mathematical development of certain aspects of quantum theory that are only outlined in the text. Several of the appendices are devoted to the details of some of the applications of the theory to solids. As an additional aid to the student, sets of problems are included at the end of each chapter.

It is almost inevitable in a work of this scope that certain topics will be discussed less thoroughly than others. The chapters on the electrical and magnetic properties of matter are excellent. On the other hand, mechanical, chemical, and thermal properties of matter are treated together in a single short chapter. The liquid state was mentioned only briefly and then in reference to other subjects. Order-disorder phenomena were not treated. One wishes occasionally that more detail had been included; however, it must be remembered that space is not unlimited and that the text is intended to be intermediate in nature.

In the opinion of this reviewer, the advantages of the treatment the author has chosen far outweigh the disadvantages. It is felt that the purpose of the book, as stated by the author, "to encourage the reader to think for himself, to regard what he is learning as a tool for further development, rather than a set of facts to be remembered," has been more than adequately fulfilled.

J. H. Crawford, Jr.
Oak Ridge National Laboratory

The Injurious Insects of the British Commonwealth. (Except the British Isles, India, and Pakistan.) J. W. Evans. Commonwealth Institute of Entomology, London. vii + 242 pp. £1 10s.

THIS beautifully printed compilation is hardly a worthy tribute to Sir Guy A. K. Marshall, K.C.M.G., D.Sc., F.R.S., and director of the Imperial Institute of Entomology from 1915 to 1942, whose frontispiece portrait is its only illustration. "No one has done more to advance the cause of Commonwealth cooperation," but *his* entomological interests were worldwide, and not limited as in this publication, the scope and plan of which was changed and reduced as it was being written.

The treatment of the insects of medical and veterinary importance is grouped by territories, introduced with a short account of the geography of each, its climate, crops, the early entomologists, comprehensive publications, and the principal insect pests of plants. A list of insects arranged by economic host plants follows. Under the systematically arranged scientific names of insects, the economic pests of agriculture, horticulture, and forestry and notes on injury and distribution, varying from a single line to several pages, comprise two thirds of this slim volume. In general, these notes are adequate summaries of the published literature, but some may not with entire accuracy reflect actual field conditions. Cotton growers in Texas, where 25 counties outside the quarantine area of 1952 have been found infested with pink bollworm, would hardly agree that "its importance has declined." Elsewhere farmers have found that profitable cotton growing is impossible with pink bollworm: either the injury is too severe, or control costs too much. Thus its culture is discontinued, entomologists cease reporting, and "its importance has declined."

No insecticide is mentioned by name, and only the more important parasites. "Only references relating to the Commonwealth countries have been consulted, although in very many instances the insects mentioned occur and have been studied elsewhere." No bibliography is given; references to literature are to volume and page of the *Review of Applied Entomology.*

George N. Wolcott
Agricultural Experiment Station
University of Puerto Rico
Rio Piedras

Traité de Pisciculture. Marcel Huet. xiv + 369 pp. Illus. Paper-bound, 210 Belgian fr.; cloth-bound, 285 Belgian fr. Edition la Vie Rustique, 299, Avenue Georges-Henri, Brussels. 1952.

IN COMPILING this book, Professor Huet has set himself a difficult task—namely, to give in a single volume a comprehensive and practical account of all branches of fish culture. Many volumes have been written on certain aspects of the culture of fish, including trout, salmon, carp, pike, etc., but this is the first time that an attempt has been made to condense this vast amount of information in a single volume. Huet, a student of the late Professor Léger, of France, devoted years to the study of fish culture in many countries. On the basis of this wide knowledge, he has compiled a most useful guide on fish culture. The book begins in a very logical way with an account of the construction and management of ponds. This is followed by a chapter on the feeding of fish in general, undoubtedly the most important aspect of fish culture, which is consequently dealt with very thoroughly. Carp culture, salmonid culture, and what Huet terms special fish culture are described in separate chapters. The latter chapter covers the culture of pike, coregonids, black bass, tilapia, and eels.

Chapter VI deals fully with the stocking and productivity of ponds. Here again Huet has broken new ground in providing fish culturists with simple formulas for determining the stocking rate of ponds and their potential productivity. In Chapter VII a detailed account is given of pond management, including the control of vegetation and the application of lime and fertilizers.

The final chapter deals with the removal of the

fish crop and sorting and transporting the crop to market. An extensive literature list is given at the end of the book. This is arranged under the same headings as the chapters of subject matter, thus indicating at a glance the source from which the latter has been derived.

Printed on art paper and copiously illustrated, this book is a valuable acquisition to the library of any fish-cultural station.

D. Hey

Province of the Cape of Good Hope
Stellenbosch, South Africa

The Old Egyptian Medical Papyri. Chauncey D. Leake. v + 108 pp. $2.00. University of Kansas Press, Lawrence. 1952.

OUR knowledge of the medical practices and beliefs of ancient Egypt is derived to a great extent from the study of eight papyri. Careful analysis of these documents was made by Grapow in a series of scholarly German articles, and they were ably summarized by Sigerist in the first volume of his important *History of Medicine.*

Dr. Leake makes a definite contribution of interest to members of the medical sciences, in his review of these records. The thin series of lectures presents the material in brief, succinct style, and draws some conservative conclusions. It certainly demonstrates, once again and forcibly, that "primitive medicine" cannot be considered as an entity but relates to the specific area, its people and their culture, and that the professional standards and achievements of its medical practitioners must be divided sharply from the popular attitudes and beliefs regarding disease by the general population.

Michael B. Shimkin

Claude Bernard and the Experimental Method in Medicine. J. M. D. Olmsted and E. Harris Olmsted. ix + 277 pp. $4.00. Henry Schuman, New York. 1952.

THIS book is another chapter in the long-term study of the career of the greatest physiologist of them all, by a noted contemporary physiologist and his wife. As the title indicates, emphasis is placed upon the development and application of the scientific method of physiology. This approach has tended to obscure the personal, human aspects of Bernard, so that the book falls considerably short of the warmth and depth of Valerie-Radot's story of Pasteur. And the development of experimental medicine has already been recorded by Bernard himself in the immortal *Introduction.*

The authors' sympathy for Bernard has not disguised the apparent fact that Bernard must have been somewhat less than a success as a husband and father. Mme. Bernard may have been a shallow, narrow-minded woman who did not appreciate the genius of her husband, but her side of the story is unfortunately not recorded, except by the mute testimony that the influence of the only male of the family was such that neither of their two daughters ever married. The role of Mme. Raffalovich certainly deserves further study. In this book she is introduced as the brilliant "wife of a Russian-Jewish financier living in Paris." What happened to the financier is not revealed, but I would consider him a major hero in his apparently quiet and understanding tolerance of his wife's relationship with Bernard.

Michael B. Shimkin

Laboratory of Experimental Oncology
National Cancer Institute
National Institutes of Health, USPHS, and
Department of Medicine, Cancer Research Institute
University of California School of Medicine
San Francisco

Dynamic Aspects of Biochemistry. Earnest Baldwin. 544 pp. $5.00. University Press, Cambridge, England. 1952.

PROFESSOR Baldwin maintains in this, the second edition of his well-known book, the excellence that led to the enthusiastic reception of the first. The publishers merit a special note of commendation for keeping the price unchanged, although nearly a hundred pages have been added.

Certain of the chapters have been only slightly changed, but others, as advancing knowledge has demanded, have been markedly rewritten, noteworthily those on the Aerobic Metabolism of Carbohydrates, the Metabolism of Fats, and a number dealing with enzymes. Over half the pages added are in Part I, which, in large measure, has been expanded and reorganized to include new chapters on Biological Energetics and Transferring and Isomerizing Enzymes and to devote separate chapters to Oxidizing Enzymes and Dehydrogenase Systems. The new chapter on Biological Energetics has brought together and extended ideas scattered throughout the first edition. The fruitful concept of the "energy-rich bond" is applied clearly. In passing, reference may be made to the objection of physical chemists to this expression. It would be well if some less objectionable terminology could be suggested and generally adopted by biochemists. The bibliography—as in the first edition, a list only of review articles and books—has been considerably expanded.

The more excellent the book, the more striking the errors. The wrong formula for kynurenic acid (p. 298) has been carried from the first to this edition. The statement that lysine "is believed not to undergo deamination in the body" (p. 294) is surely not meant, as the incorporation of isotopic N from lysine into other amino acids has been demonstrated. Perhaps reversible transamination was in mind (*cf.* p. 269). On page 56, the quotient for K is inverted, and the expression given for Δ F really applies to the standard value Δ F°. Clarification of the relationships involving these values would be desirable.

This new edition may be warmly recommended to teachers, students and all others who desire a clear ex-

position of present understanding of a large area of biochemistry, intermediary metabolism.

RALPH C. CORLEY

Department of Chemistry
Purdue University

Mathematics at the Fireside. G. L. S. Shackle. xii + 156 pp. $3.25. Cambridge University Press, New York. 1952.

THIS book is motivated by a novel idea: To give youngsters (those on the frontispiece illustration seem about ten to twelve years old) a grasp of some of the great, basic notions of mathematics, such as limit of sequence, mathematical induction, integration, etc., although one usually first studies these concepts at the university level. The method is by informal conversations between an adult and two youngsters, branching off from some familiar activity. For example, integration is associated with seeding an irregularly shaped lawn.

The reviewer feels that many youngsters can master and enjoy most parts of the book, especially with a little encouragement from an adult. (Very probably the adult will also enjoy the material simultaneously). He has tried out parts on two youngsters with definite success. But a more significant sample is required for adequate experimental evaluation. As is inevitable, some rough spots exist—namely, finding the roots of a quadratic. A suggestion can be given which might make things more true to life and so more exciting. The youngsters should at times give incorrect answers and ask questions that steer in wrong directions rather than always be right.

The author is to be commended for this fine piece of pioneering work. Children should not only be trained to manipulate, but should also be given a "feeling" for, the underlying ideas.

JOSHUA H. ROSENBLOOM

Naval Ordnance Laboratory

Metallurgy for Engineers: Casting, Welding, and Working. John Wulff, Howard F. Taylor, and Amos J. Shaler. 624 pp. Illus. $6.75. Wiley, New York. 1952.

THIS is a textbook intended for use in teaching metallurgy to engineering students. The first half of the book explains the principles of physical metallurgy involved in the fabrication of metals into useful shapes, and the latter half presents details of processing practice. The book is well organized for undergraduate use; helpful supplements to the text are the concise summaries, definitions, review questions, and references found at the end of each chapter. The excellence and clarity of the book as a teaching aid are enhanced by the illustrations prepared by George E. Schmidt, Jr.

The authors have succeeded in describing the principles of metallurgy and defining its terminology in language familiar to the engineer, without resorting to inaccurate, oversimplified, or out-moded concepts. The concise, authoritative treatment of metallurgical principles recommend the book, not only as a text for engineering students, but also as a review for practicing engineers and metallurgists who may not have maintained continuing contact with metallurgical developments outside their own branches of specialization.

The distinguishing feature of the book is the excellent coverage of metal-processing practice, which includes casting, powder fabrication, welding, and working. In the field of casting, six chapters are devoted to sand casting, other casting processes, the ingot as a casting, melting including heat flow and gases in metals, casting defects and their control, and gating and risering practice. Five chapters cover welding and joining processes. Additional chapters include powder metallurgy, compression working processes, metal cutting, and stretching, shearing, and bending processes.

The stated aim is to give the engineering student an adequate understanding of metals, so that he may intelligently select and use them. If the book has any shortcoming in the accomplishment of this objective, it may be the limited treatment of the significance of static and dynamic properties of metals, particularly as they are related to fatigue failure and brittle fracture.

E. C. MILLER

Metallurgy Division
Oak Ridge National Laboratory

My Brother, My Enemy. Mitchell Wilson. 372 pp. $3.75. Little, Brown, Boston. 1952.

WE HAILED *Live with Lightning*, Mitchell Wilson's previous book, as "science made interesting in a spectacular novel" and were amazed "that a book of interest to science should be, as well, an absorbing novel." For this second book, concerned with the beginnings of television, that evaluation is again valid.

Here we see two young men, Davy and Ken Mallory, filled with the dream of inventing the transmission of a moving image. They were pioneers in the idea but felt the need to work fast before someone else should perfect it. In all their reading they found no suggestion of other workers, but they knew that in every scientific discovery several men arrived at a conclusion within days of one another.

The boys were orphans; they had no money beyond what they could earn in their garage and what their sister, Margot, could earn for them. Yet, because Margot shared their ambition, they worked on electronics back of the garage and studied at the university. As soon as they had their degrees it was necessary to find a financial backer who would provide not a few, but thousands, of dollars. Their adventures in that direction led them into strange and difficult company; promised funds were not forthcoming; new approaches had to be found.

Meanwhile their every effort was to discover the perfect vacuum tube. For "it was Davy's conception that by the tube's mere existence, raw electricity had

taken on the malleable character of a medium for man's endless creativity." Each trial was made with high hopes; each failure was met by the will to succeed. They knew they were right and nothing would deter them from achievement. They felt "about [inventive] engineering in the same way that composers do about music" and knew "the terrific thrill of making something exactly the way you think it should be made."

Work came first to both Davy and Ken—although they were working for different reasons—but they were entirely normal young men. They took time for girls and sports, for friendship and some enmity. If the book be read as a novel (apart from science), the stories of Vicky who eventually married Davy, of Margot and her millionaire, of old Norton Wallis, combustion engineer, and of the circus man Carl Bannerman are fascinating. How many people, other than the reviewer, enjoy a mixture of science and fiction, of real and make-believe, we can't guess. With an outstanding book like this, there should be thousands; it makes electricity intelligible and scientific effort enthralling.

MARJORIE B. SNYDER

Washington, D. C.

Freshwater Fishery Biology. Karl F. Lagler. 360 pp. Illus. $5.75. Wm. C. Brown, Dubuque, Iowa. 1952.

FISHERY biology is an applied science which, for its successful execution, requires the use of methods and ideas developed in many different fields of scientific endeavor. As a result, a concise, clear-cut pronouncement of these methods and ideas, which at the same time is healthy with criticism is a difficult task, requiring considerable practical as well as theoretical knowledge. That Dr. Lagler is equal to the task is amply demonstrated throughout this book, which is the first text on the subject in North America.

Designed largely for student consumption, the 25 chapters are concise yet sufficiently detailed to provide a well-balanced working knowledge of the subject under discussion. Each chapter has approximately the same outline—namely, the definition and purposes of a particular study, the various methods and equipment developed to obtain the pertinent information, a study program, and selected references. For the most part, each chapter is well illustrated, the methods are adequately criticized, and the study programs well thought out.

The material in the book falls into four unequal sections. Chapters 1 to 15 cover the investigational aspects of the work relating to the natural history and ecology of fishes, classification, literature, embryology, food habits, age and growth, population studies, yield, diseases, and pollution. Chapters 16 and 17 treat management methods, such as laws and fish culture (propagation and stocking), with Chapters 20 and 22 treating lake improvement and stream improvement, respectively. Chapters 18, 19, and 21 deal with the methods employed in topographical, physical, chemical, and biological surveys. The final three chapters discuss the creation of new fishing waters (ponds and reservoirs), commercial fisheries, and recreational fisheries. Throughout the book the author never forgets his purpose—that of presenting methods for investigating and manipulating fish populations and their environment in order to obtain the greatest sustained yields.

Although an outgrowth of Lagler's previous publication *Studies in Freshwater Fishery Biology,* which was largely a laboratory manual, the present work is greatly improved. The old perforated work sheets of the laboratory manual, with their tendency to stultify the student by "blank-filling," have been relegated to their proper level in the appendix. One text has been completely reworked, with unnecessary examples and work data being replaced by illustrations and additional pertinent material. As in the old work, the reference list is up to date and complete.

On the opposite side of the ledger, there are a few discrepancies that should be pointed out. In Chapter 2 a checklist of fishes north of Mexico is given as "representative." Actually, the list includes approximately 70 per cent of the fishes of the Great Lakes region but less than 40 per cent of the fishes of the Southwest. This latter figure is hardly representative. This may, however, be more of a commentary on the lack of published material in the Southwest rather than an oversight by the author. In the chapter on pollution (p. 165) an old error first stated by Ellis is repeated—that water quality favorable to warm-water stream fishes should have dissolved oxygen not less than 5 ppm. It is common knowledge throughout the South that the large, slow-flowing rivers high in organic matter frequently have oxygen content much less than 5 ppm for considerable periods, yet they sustain good populations of catfish, drum, and buffalo, as well as considerable numbers of centrarchids. On page 220, Figure 93, a thermally stratified lake is shown with the hypolimnion devoid of fish. For a book that deserves widespread use over the whole of North America, this is misleading, since without large hypolimnia, with their great supply of oxygen and cold water which enable the lake trout, white fish, and ciscoes to survive the critically high summer temperatures, the valuable freshwater fisheries of Canada would be nonexistent.

The publisher has done an excellent job by using large, easy-to-read type on the highest quality glossy paper and by holding the typographical errors down to the usual few. Unfortunately, two photographs on page 224 are marred by streaks, and the letter "a" in the various formulas is printed in the same style of type as the text, resulting in some confusion when the formulas are explained. Except for these minor items, however, the author and publisher should be congratulated for the fine job they have done in producing this much-needed book.

FRANK T. KNAPP

Department of Wildlife Management
Agricultural and Mechanical College of Texas

Plants of the Bible. Harold N. Moldenke and Alma L. Moldenke. Vol. 28 of "A New Series of Plant Science Books." xx + 364 pp. Illus. $7.50. Chronica Botanica, Waltham, Mass.; Stechert-Hafner, New York. 1952.

IN THE index to this erudite compilation is a list of 63 different Bibles, and a new one has just been announced as a "Revised Standard Version." All of them differ in text and content, and few of their sponsors appear to be tinged by any traffic with Tom Paine. Nor should they be, for the Bible is for the faithful and hence, quite literally, out of this world.

Unhappily, many botanists, of varying degrees of pietistic fervor and technical equipment, have striven to untangle the maze of Biblical references to plants. The task is scientifically impossible, and the present attempt is full of "probably," "may be," "considerable doubt," and a dozen other expressions of bewilderment. When the Biblical *lily* is (probably) an anemone, the *juniper* a broom, the *mulberry* an aspen, the *rose* an oleander, and the *apple* an apricot, botanists must wonder why these authors chose to tread in fields so barren of certainty.

They may also wonder why the best botanical publishing house in the country should have issued such an expensive book on a subject of no real interest to science. The authors admit that, of 230 species of plants, over 150 are so uncertain that they are not sure whether the Biblical names can ever safely be linked with any known plant. Some 60 plants, such as the fig, pomegranate, cedar of Lebanon, olive, etc., seem to them reasonably certain as to identity.

The book is wonderfully indexed, all the plants of the Bible being cross-referenced by their Biblical, English, Hebrew, and technical names. Unfortunately, such erudition, and a bibliography of more than 600 titles, must leave the botanist wondering why so much talent went into a field where tares are more plentiful than wheat.

NORMAN TAYLOR

Elmwood, Princess Anne, Maryland

SMO ON THE AIR

STATION	SPONSOR	TIME
	Monday	
WOI-FM, Ames, Iowa	Iowa State College of Agriculture and Mechanic Arts (Articles of Interest)	7:45 P.M.
	Tuesday	
WEVD, New York City	Wendell W. Rázim (Science for the People)	9:00 P.M.
	Wednesday	
CKPC, Brantford, Ont.	The Telephone City Broadcast Limited (Modern Science)	9:45 P.M.
	(Irregular)	
KBER, Baker, Ore.	Baker-Union Department of Health (Research Report)	....

The Editor of THE SCIENTIFIC MONTHLY will be glad to cooperate with university or other educational stations interested in securing scientific material suitable for broadcasting.

LETTERS

ES SCHIESST DOCH!

THE apparent attempt at humor on pages 259–62 of the October SCIENTIFIC MONTHLY seems, in spite of the beautiful photographs, a long way below the ordinarily excellent standard of the journal.

F. R. FOSBERG

Falls Church, Virginia

Dr. Fosberg is a botanist who specializes in the taxonomy and distribution of higher plants, especially those of the Pacific Islands.

THE story entitled "The Schuss-Yucca" is a very interesting account of an unusual natural phenomenon. However, an examination of the photographs taken at one-second intervals (as stated by the author) reveals an even more spectacular phenomenon, which I am amazed that he has neglected to mention. In the four- or five-second interval over which these five pictures were taken, the sun moved through about 45 degrees of arc, as shown by the progressive change in position of the shadows of the model and the yucca flower.

THOS. C. POULTER

Stanford Research Institute
Stanford, California

Dr. Poulter won first place in the Color Division, International Photography-in-Science Salon (sponsored by THE SCIENTIFIC MONTHLY *and the Smithsonian Institution), in 1947; first place with Walter K. Lawton in 1948; and third place (with Mr. Lawton) in 1949.*

IT IS gratifying to note that THE SCIENTIFIC MONTHLY is ever becoming more widely recognized as an authoritative source of scientific information. The latest confirmation of this is in the "What Scientists Are Doing" column of the New York *Herald Tribune* (Sunday, Oct. 26 [1952]), where under the heading "Stalk Grows 10 ft. in 2 Mins." are summarized the main facts contained in the communication from Gustav Albrecht on "The Schuss-Yucca."

Without wishing to minimize the notable contribution of Dr. Albrecht in presenting incontrovertible proof of the existence of this strange phenomenon, I am surprised that he apparently failed to note a rather remarkable accompanying phenomenon which is described in detail by Grünspann in his *Handbuch der Yucca,* a complete set of which I am fortunate enough to own. This occurrence, the recital of which formed the basis of some of the more vicious attacks on Professor Grünspann, is found on pages 813–976, Vol. 13, of the *Handbuch.* Here he describes in some wonderment the fact that during the precise period while the plant was shooting (*war schussingen*) the sun appeared to behave in a most extraordinary manner and actually seemed to race around the earth on its normal path some fourteen or fifteen times. Grünspann makes no attempt to explain this action but merely records it with coldly scientific objectiveness (*"Himmel! Was gibt? Es gibt Sumdings zertänlich wie ein moanki Bizness. . . ."* (p. 843).

Dr. Albrecht's photographs give strong qualitative, if not quantitative, confirmation of this. Comparing the length of the shadow cast by the young lady in the first (or even the third) photograph with that in the fifth, or last, picture it is very apparent that *in the course of only a few seconds* the sun appears to have changed its position by an amount reckoned in *hours* (or, of course, days) by ordinary time. Thus here we have again *photographic proof* of one of the more controversial claims of Professor Grünspann.

The course of scientific pioneering is rough and beset with pitfalls, but for the encouragement of us all it is still a law of nature that truth must ultimately prevail.

O. C. BREWSTER
Connecticut Registered Professional Engineer
New York State Licensed Professional Engineer
Litchfield, Connecticut

I AM submitting for publication an account by an eyewitness of an even more amazing botanical phenomenon than that of the Schuss-yucca. . . . In my opinion, it will be your only effective answer to those who question the authenticity of the remarkable flowering of the Schuss-yucca. . . .

SAM F. TRELEASE

Department of Botany, Columbia University

. . . My heart resembles more that heavy, fantastic flower from the woods of Brazil which, according to legend, only blooms once every century. I remember seeing such a flower when I was a boy. We heard in the night a shot as from a pistol, and on the next day the neighbor's children told me that it was their aloe which had bloomed up suddenly with such a thundering report. They led me into their garden, and there I saw, to my astonishment, that the low, hard growth with its foolishly broad, sharply pointed leaves, on which one could easily injure oneself, had now shot up high, and was bearing the most glorious blossom on top, like a golden crown. We children could not look up so high, and the old, grinning Christian, who was fond of us, built a wooden staircase around the flower, and we clambered up on it like cats and gazed curiously down into the open calix, out of which the yellow stamens and wildly strange scents thronged with unheard-of splendor.

Yes, Agnes, often and easily this heart does not bloom; as well as I can remember, it has bloomed but a single time, and that may well have been long ago, certainly a hundred years. I believe, though its blossom developed so gloriously then, yet it would have pined away for lack of sunshine and warmth, if it had not been violently destroyed by a dark winter's storm. Now, however, there is hurry and movement again in my breast,

and if you suddenly hear the shot—maiden, be not afraid! I have not shot myself dead, but my love is bursting its bud and is shooting up in radiant songs, in eternal dithyrambs, in happiest fullness of song.*

**The Sea and the Hills: The Harz Journey and the North Sea.* Heinrich Heine. Translated by Frederic T. Wood. Chapman & Grimes, Boston. 1946 (originally published about 1830).

GUSTAV ALBRECHT's account of the Schuss-yucca, which appeared in your October 1952 issue, was read by me with considerable satisfaction. As a long-time student of this interesting plant, I should very much like to bring the record up to date. I have at hand a copy of the *Handbuch der Yucca* (Leipzig: Schmutzig-Verlag [1893]). Apparently Dr. Albrecht had not seen the second edition, *Handbuch der Yucca, illustrierte zweite Auflage* (Leipzig: Schmutzig & Dreckig-Verlag [1913]). It seems that some time in 1910 Schmutzig Senior died. The old firm was taken over by his son, who subsequently associated himself with Herr Dreckig, and the Verlag became known under the new name shortly before World War I. The firm went out of existence, however, during World War II.

The second edition of the *Handbuch* contains quite a good deal of new information, of which the following is of some interest. Several French scientists had read Professor Grünspann's twenty-volume introduction to the study of the yucca, and in 1911 two of them set out to verify the Schuss-yucca phenomenon. These two eminent botanical researchers were Cyprien Lablague, of the Sorbonne, and Aristide Gaillard, of the Collège de France. They reasoned (accurately) that if deer could instinctively divine which yucca plants to watch, other animals might do it even better. They thought immediately of the pigs that had been used for centuries by French peasants to locate truffles (*Tuber melanosporum*) in the Périgord region of France (see TRUFFLE, *Encyclopaedia Britannica*, 507 [1943]). It is well known that these especially trained animals have such an acute sense of smell that they can unfailingly scent the subterranean tubers; it is claimed that the pigs squeal loudly the instant they come near the underground plant.

With the aid of several of these pigs, then, the French botanists observed and photographed many Schuss-yuccas, completely vindicating Professor Grünspann. In the last *Handbuch* numerous photographs of the plant in action are reproduced. These are not as good, however, as those of Dr. Albrecht, who had the advantage of being able to use a live model and streamlined modern photographic equipment.

Messers. Lablague and Gaillard also added some most interesting new findings, which would seem to point to the real reason lying back of the astonishingly fast growth of the yucca. As mentioned by Professor Albrecht, the Chilao Flat region is heavily infested with rattlesnakes (*Crotalus atrox*). The French scientists were able to ascertain that the rattlesnake invariably seeks out a yucca before shedding its skin. In its struggles, it takes firm hold of the yucca roots and shakes off the old skin. During this process, the snake inevitably bites into the roots, and some of the rattlesnake venom is injected into them. The French team made the further discovery that the venom contains small percentages of the powerful enzymes hyaluronidays and hyaluronites. These are considered to be the chief reason for the extraordinarily rapid growth of the Schuss-yucca.

This year, while I was in California, I happened to mention the matter to two Stanford University electronics physicists, and we decided to explore the subject further. Accordingly, we designed a millimeter-wave radio receiver, connected to a rotary search radar. On location we found that, with the radar antenna revolving, we frequently got blips on the cathode-ray screen from various directions, but always pointing to yuccas. Preliminary computations, based on 98 responses (discrepancies in two observations are still unresolved), have led to the tentative conclusion that the yucca plant, *24 hours before it starts to shoot*, actually sends out impulses on a wavelength close to 60 kilomegacycles. Instrumentation thus promises to provide a more scientific predictive and observational method than the use of deer or pigs, because the observer has 24 hours in which to set up photographic equipment near the plant before it starts to shoot.

The preceding account is only a preliminary report. Final results will be made known in about a year, after further scientific data have been recorded and analyzed.

HUGO GERNSBACK
Member, American Physical Society
Member, American Association for the Advancement of Science
Radio-Electronics, *Radcraft Publications, Inc.*
New York

The Editors will welcome similar communications from other readers who have firsthand knowledge of the Schuss-yucca. There is reason to believe that any new observations will be included in the presumptive third edition of the Handbuch.

ASSOCIATION AFFAIRS

AAAS SYMPOSIA AT THE ST. LOUIS MEETING

CHARACTERISTICALLY, AAAS symposia explore relatively neglected areas of scientific inquiry, constitute up-to-date surveys of knowledge in particular fields, or are concerned with the interrelations of science and human welfare. Such programs are significant and valuable because they focus attention upon critical areas, summarize the present status of current research, and provide viewpoints from which to direct further research. In general, these programs originate in the minds of the officers of the eighteen sections and subsections of the AAAS and are developed by them or by others whom they deputize as program chairmen. Often the sectional symposia are concerned with interdisciplinary problems and are sponsored by two or more sections; participating societies also may collaborate. If the potential demand warrants it, the papers are gathered together and published by the Association as symposium volumes.

In recent years the practice has become well established of arranging several symposia of especially wide interest or timeliness for each annual meeting. The responsibility for developing these general symposia, sponsored by the Association as a whole, rests upon a Symposium Committee, appointed each year by the president of the Association. Upon occasion, a proposed sectional program may be chosen to be developed as a general symposium; more commonly, the Symposium Committee, which represents a variety of scientific fields, itself plans and arranges these general sessions. The committee may invoke the aid of consultants and appoint others to implement the general symposia, and it calls freely upon authorities to function as chairmen at the sessions.

The 1952 Symposium Committee consists of Detlev W. Bronk, president of The Johns Hopkins University and of the AAAS (*chairman*); William A. Albrecht, chairman, Department of Soils, University of Missouri; Edgar Anderson, Engelman professor of botany, Washington University, and assistant director, Missouri Botanical Garden; Arthur H. Compton, chancellor, Washington University; Edward A. Doisy, Sr., director, Department of Biochemistry, Saint Louis University School of Medicine; Charles Allen Thomas, president, Monsanto Chemical Company, and general chairman of the St. Louis Meeting; Carl Tolman, dean, Graduate School of Arts and Sciences, and chairman, Department of Geology, Washington University; John W. Tukey, Department of Mathematics, Princeton University; Clyde E. Williams, director, Battelle Memorial Institute; Conway Zirkle, Department of Botany, University of Pennsylvania; and Raymond L. Taylor (*secretary*).

Of the general symposia at this year's meeting, "Disaster Recovery" was originally proposed by the AAAS Section M Committee; "The Nation's Nutrition" was suggested by Edward A. Doisy, Sr.; and "Applications of the Theory of Games" was conceived and organized by John W. Tukey.

General Symposia

I. **Disaster Recovery.** Saturday morning and afternoon, Dec. 27. Arranged by Howard A. Meyerhoff.

Part 1. The Nature of Disasters

Lloyd V. Berkner, president, Associated Universities, Inc., *Presiding*

1. The Common Aspects of Disasters. Lloyd V. Berkner.
2. Natural Disasters. James B. Macelwane, dean, Institute of Technology, Saint Louis University.
3. Industrial Disasters. G. M. Kintz, chief, Accident Prevention and Health Division, Region VI, U. S. Bureau of Mines, Dallas.
4. Mine Fires and Explosions. James Westfield, chief, Health and Safety Division, U. S Bureau of Mines, Washington, D. C.
5. Psychological and Sociological Factors in Disasters. Donald G. Marquis, chairman, Department of Psychology, University of Michigan.

Part 2. Disaster Recovery

Ernest E. Howard, consulting engineer, New York, and Kansas City, Mo., *Presiding*

1. Emergency Measures—the Human Element. Robert C. Edson, assistant national director, Disaster Services in Charge of Rehabilitation, American National Red Cross, Washington, D. C.
2. Emergency Repair of Public Works and Public Utilities. Kenneth M. Kent, Civil Engineer Corps Officers' School, Bureau of Yards and Docks, Department of the Navy.
3. Restoration of Communications. Rudy Eklund, general plant manager, Southwestern Bell Telephone Co., Topeka, Kan.
4. Re-establishment of Transportation. R. P. Hart, chief operating officer, Missouri Pacific Railroad, St. Louis, Mo.
5. Restoration of Community Functions. Frank P. Zeidler, mayor, City of Milwaukee.
6. The Basic Elements in Disaster Recovery. Ernest E. Howard.

II. **Applications of the Theory of Games.** Monday morning, Dec. 29. Arranged by John W. Tukey.

A. W. Tucker, Princeton University, *Presiding*

1. General Introduction. John von Neumann, Institute for Advanced Study, Princeton, N. J.
2. Conflicts with Imprecise Payoffs. John D. Williams, chief, Division of Mathematics, Rand Corporation, Santa Monica, Calif.
3. Business and Industry. John McDonald, Board of Editors, *Fortune* Magazine, New York.

III. **The Nation's Nutrition: From Soil to Cytoplasm.** Tuesday morning and afternoon, Dec. 30. Arranged by Howard B. Lewis, professor and head, Department of Biological Chemistry, University of Michigan Medical School.

Part 1. Sources of Food.

Howard B. Lewis, *Presiding*

1. Soils and their Relation to Food Production. Lloyd M. Turk, professor and head, Department of Soil Science, Michigan State College.
2. Foods of Plant Origin. George R. Cowgill, professor of nutrition, Department of Physiology, Yale University.
3. The Production of Foods of Animal Origin. Roy C. Newton, vice president in charge of research, Swift & Company.
4. The Deterioration of Food and Foodstuffs. E. C. Stakman, professor and chief, Division of Plant Pathology and Botany, University of Minnesota.

Part 2. Assimilation of Food.

Edward A. Doisy, Sr., *Presiding*

1. General Biochemistry and Health Relationships of Nutrition. C. Glen King, professor of chemistry, Columbia University, and scientific director, Nutrition Foundation, Inc.
2. Protein Requirements of the Diet. James B. Allison, professor of physiology and biochemistry, and director of the Bureau of Biological Research, Rutgers University.
3. Fats and Carbohydrates in the Diet. Harry J. Deuel, Jr., professor of biochemistry and dean, Graduate School, University of Southern California.
4. Vitamins and Minerals. Conrad A. Elvehjem, professor and chairman, Department of Biochemistry, and dean, Graduate School, University of Wisconsin.

Sectional and Society Symposia

B—Physics

Nuclear Science in Industry; arranged by Ralph T. Overman.

Research Applications of Carbon 14; arranged by Ralph T. Overman.

Magnetic Resonance and its Applications; arranged by Arthur L. Hughes.

Tornadoes and Tornado Forecasting; arranged by Edward M. Brooks.

C—Chemistry

The New Synthetic Fibers (two sessions); arranged by Frank J. Soday.

Contributions of Chemistry in the Field of Human and Animal Nutrition (two sessions); arranged by Barrett L. Scallet.

Contributions of Chemistry to Medicine; arranged by Kenneth N. Campbell.

Chemistry and Dentistry Team Up for Progress (two sessions); arranged by Frances Krasnow.

Contributions of Chemistry to the Cancer Problem; arranged by Kenneth N. Campbell.

Liquid Fuel Supplies of the Future and the Impact on the Chemical Industry of Chemicals Available as Co-products from Synthetic Fuel Processes (two sessions); arranged by L. L. Hirst.

Contributions of Chemistry to Agriculture (two sessions); arranged by Lloyd V. Sherwood.

E—Geology and Geography

Modern Research of State Geological Surveys and its Economic Values (two sessions); arranged by M. M. Leighton.

F—Zoological Sciences

The six following programs were all arranged by R. E. Blackwelder

Public Book Discussion Panel: *Time's Arrow and Evolution.*

Public Book Discussion Panel: *The Meaning of Evolution.*

Life History Studies in Relation to Systematics.

Anecdotal Sketches of Famous Zoologists.

Public Book Discussion Panel: Three College Biology Texts.

Public Book Discussion Panel: Three College Zoology Texts.

G—Botanical Sciences

Improvement in the Teaching of Taxonomy; arranged by Aaron J. Sharp.

Biosystematics and Taxonomic Units; arranged by Edgar Anderson.

Nitrogen Metabolism in the Green Plant (two sessions); arranged by Barry Commoner.

The Western Range—Our Great Natural Resource; arranged by F. W. Albertson and David F. Costello.

Plant Sociology and the Taxonomy of Vegetational Units (two sessions); arranged by Stanley A. Cain.

H—Anthropology

The Plains and the Rio Grande Pueblos; arranged by James B. Watson.

I—Psychology

Men and Machines (two sessions); arranged by Philip H. DuBois.

Problems in Psychotherapy; arranged by Robert I. Watson.

K—Social and Economic Sciences

Social and Economic Aspects of Technical Assistance Programs (three sessions); arranged by Conrad Taeuber and Gordon Macgregor.

Information Processing in Social and Industrial Research; arranged by Amos E. Taylor.

Regional Research: Emerging Concepts and Techniques; arranged by Walter Isard.

The Individual Scientist in Today's World; arranged by Franklin Miller, Jr.

L—History and Philosophy of Science

Relations between Science and Thomistic Philosophy; arranged by Raymond J. Seeger.

Methodology of Engineering Research; arranged by Raymond J. Seeger.

Leonardo da Vinci; arranged by Raymond J. Seeger.

Philosophical Problems of Contemporary Biology; arranged by Henry Margenau.

Confirmation of Scientific Theories; arranged by Henry Margenau.

M—Engineering

Hearing and Speech Aids; arranged by Eugene F. Murphy.

N—Medical Sciences

Survival of Frozen Tissues, Normal and Tumors (two sessions); arranged by B. J. Luyet.

Nm—Medicine

Fluid and Saline Therapy; arranged by Carl A. Moyer.

Chemotherapy of Tuberculosis; arranged by Alfred Goldman.

The Social Sciences and Humanities in Medical Education; arranged by Hugh E. Setterfield.

Industrial Hygiene: An Applied Science; arranged by Elmer P. Wheeler.

Health Hazards and Health Protection (three sessions); arranged by Gordon K. Moe.

Nd—Dentistry

The Chemistry of Saliva; arranged by F. J. McClure and Isadore Zipkin.

Scientific Contributions to the Manufacture of Restorative Dental Materials; arranged by Floyd A. Peyton.

Engineering and Chemical Factors of Water Fluoridation; arranged by A. P. Black.

Np—Pharmacy

Programs arranged by George F. Archambault

The Accreditation of Hospital Pharmacies and the Approval of Pharmacy Interne and Residency Programs.

Content of Hospital Pharmacy Courses in Schools of Pharmacy.

The Role of the USP, the NF, the NNR, and the ADR in Developing and Maintaining Sound Drug Therapy Trends and Standards.

Medical Societies

Problems in Forensic Sciences (two sessions); arranged by Ralph F. Turner and R. B. H. Gradwohl.

Science and Medical Care; arranged by E. M. Bluestone.

Education in Physiological Science (two sessions); arranged by Maurice B. Visscher, H. Burr Steinbach, and Orr Reynolds.

O—Agriculture

Combined Resource Development with Special Reference to the Missouri Valley (four sessions); arranged by Charles E. Kellogg.

P—Industrial Science

Industrial Microbiology (two sessions); arranged by J. E. McClary.

Effective Utilization of Industrial Manpower (two sessions); arranged by Allen T. Bonnell.

Q—Education

A Report of Research on the New York State Regents Examinations in Science; arranged by George G. Mallinson.

Yale Report on Attacks on Education; arranged by C. W. Scott.

Identification of Talented Youth in Science and Mathematics; arranged by Morris Meister.

X—Science in General

Conference on Scientific Editorial Problems; arranged by Marian Fineman.

Conference on Scientific Manpower, II (three sessions); arranged by Ralph M. Hogan.

Science in the News Columns; arranged by Volta Torrey.

RAYMOND L. TAYLOR

Assistant Administrative Secretary, AAAS

REVISION OF THE AAAS CONSTITUTION AND BYLAWS

IN THE October issue of THE SCIENTIFIC MONTHLY (pp. 255–58), a draft of the proposed revised Constitution and Bylaws of the Association was published in full. It was indicated that certain of the provisions were undergoing further study, and that such changes as were approved by the Executive Committee would be published at least one month prior to the Annual Meeting of the Association at St. Louis, where the Council will be asked to consider and to act upon the two documents as printed. If the Council approves, the revised Constitution and Bylaws as published in the October issue of THE SCIENTIFIC MONTHLY, with the changes that are hereinafter recorded, will go into effect one month after the Council has acted. Final drafts of the Constitution and Bylaws are being published in full in the November 21 issue of SCIENCE. Only those articles and sections that have undergone further revision are printed here. With these exceptions, the Constitution and Bylaws as printed on pages 255, 256, 257, and 258 of Vol. LXXV (No. 4) of THE SCIENTIFIC MONTHLY (October 1952) will be presented to the Council for action at St. Louis.

Constitution—*Article II*

Section 2. Members. Any person, institution, or organization may be admitted to the grade of Member. Each Member shall have such rights and privileges and shall pay such annual dues and fees as the Council shall have prescribed.

Bylaws—*Article II*

Section 3. A Member may be dropped from membership for conduct which in any way tends to injure the Association or to affect adversely its reputation, or which is contrary to, or destructive of, its objects. Charges of injurious conduct shall not be entertained against a Member unless the precise nature of the charges be submitted in writing to the president of the Association by not fewer than two Members. Upon receipt of such charges, the president shall refer them to the Executive Committee, which shall have the power to determine whether the charges shall be dropped, whether the accused shall be given an opportunity to resign, or whether the charges shall be referred to the Board of Directors for review and for final disposition. Whenever charges are referred to the Board of Directors, no person shall be dropped from membership except after opportunity to be heard and then only by a three-fourths vote of those members of the Board of Directors present and voting at a regular or special meeting.

Bylaws—*Article V*

Section 1. The committees shall be standing as provided in the bylaws or special as the Board of Directors approves.

Section 2. During the interim between meetings of the Board of Directors, an Executive Committee consisting of the retiring president, the president, the president-elect, and such other directors or administrative officers as the Board of Directors may designate shall act on behalf of the Board of Directors. All actions taken by the Executive Committee shall be submitted for review and action at the next following meeting of the Board of Directors.

Section 3. The Investment and Finance Committee shall advise the Board of Directors regarding purchases and sales of securities for the Association, shall make recommendations to the Board of Directors on financial questions, and shall have the authority to buy or sell securities under such limitations as the Board of Directors may set. The Investment and Finance Committee shall consist of the treasurer, the administrative secretary, and five (5) members appointed by the Board of Directors. Each appointed member shall serve a term of five (5) years, the term of one member expiring on January 15 of each year. Each shall serve until his successor shall have taken office.

Section 4. The Committee on Affiliation and Association shall review applications for affiliation or association with the Association and make recommendations thereon to the Board of Directors. The Committee shall consist of five (5) members appointed by the Board of Directors. Each member shall serve a term of five (5) years, the term of one member to expire on January 15 of each year. Each shall serve until his successor shall have taken office.

Section 5. The Publications Committee shall give continuing scrutiny to the publications of the Association and the policies pertaining thereto and shall make recommendations thereon to the Board of Directors. The committee shall consist of five (5) men appointed by the Board of Directors. Each member shall serve a term of five (5) years, the term of one member to expire on January 15 of each year. Each shall serve until his successor shall have taken office.

Constitution—*Article VI*

Section 3. The affairs of each section shall be managed by a section committee consisting of (*a*) the chairman and secretary of the section; (*b*) other members of the Council whose professional interests are in the field covered by the section or who represent societies affiliated with the section; and (*c*) four (4) Fellows, one elected each year by the section committee for a term of four (4) years. No person shall serve concurrently in more than one section committee. If an elected member of a section committee shall have resigned or died, his successor for the remainder of the unexpired term shall be elected from among the Fellows by the Board of Directors from nominations made by the section committee. One third of the members of the section committee shall constitute a quorum for the transaction of business.

Bylaws—*Article VII*

Section 5. Each division shall receive for its expenses an annual allowance not to exceed one dollar for each of its members in good standing and shall make an annual report to the Board of Directors covering its financial situation and other activities.

Bylaws—*Article VIII*

Section 2. Affiliated academies of science shall receive

for research an annual allowance of fifty cents for each of their members who is also a Member in good standing of the Association. The minimum annual allowance shall be fifty dollars. If any academy fails to utilize the research funds made available to it in any one year, these funds shall revert to the Association's Treasury on December 31 of the second calendar year following the year in which the allowance was computed.

Constitution—*Article XI*

Section 1. Funds of the Association shall be classified as Current Funds, Investment Funds, and Trust Funds.

a) *Current Funds* shall include all dues of annual Members, all receipts from publications, and all other funds received in the continuing operations of the Association.

b) *Investment Funds* shall include all gifts and bequests received without special restriction concerning the use to be made of principal and income, and such other funds as may be designated by the Board of Directors as investment funds.

c) *Trust Funds* shall consist of all life-membership contributions, all sustaining-membership contributions, all funds appropriated by the Board of Directors for establishing special life memberships, all gifts and bequests accepted with specific restrictions prohibiting their allotment to either Current Funds or Investment Funds, and such other funds as may be designated by the Board of Directors as Trust Funds.

Section 2. The deposit, investment, and disbursement of all funds shall be subject to the direction of the Board of Directors.

Bylaws—*Article XI*

Section 1. All funds shall be paid into the business office of the administrative secretary, where they shall be entered in the books of the Association, and deposited in a bank designated by the Board of Directors. The treasurer shall be the custodian of all Investment Funds, Trust Funds, and such other funds as may be placed in his charge by the Board of Directors. The administrative secretary shall be the custodian of the current funds.

Section 2. All bills against Members and others shall be made and collected by the business office of the administrative secretary.

Section 3. All expenditures shall be made in accordance with the budget of appropriations as adopted by the Board of Directors.

Section 4. All payments shall be made by the business office upon competent certification as to their correctness and proper authorization.

Section 5. Checks against the accounts of the Association will bear two signatures, from a list of individuals determined by the Board of Directors.

Section 6. The securities of the Association may be bought, sold, or exchanged only upon the written order of two of the following: chairman of the Investment and Finance Committee, vice-chairman of the Investment and Finance Committee, treasurer, and administrative secretary.

Section 7. The business office of the administrative secretary shall keep proper accounts of all financial transactions of the Association.

Section 8. The accounts of the Association shall be audited and approved annually by a certified public accountant selected by the Board of Directors.

Section 9. The administrative secretary shall have the authority to enter into contracts for the Association, but contract authorizations must be within the budget authorizations made by the Board of Directors.

Section 10. The activities of the Gordon Research Conference shall be administered according to procedures established by the Board of Directors.

HOWARD A. MEYERHOFF
Administrative Secretary, AAAS

John A. Behnke, formerly with W. H. Freeman & Co., San Francisco, has joined the staff of the AAAS as assistant administrative secretary. With twenty-three years in the publishing business, successively with the Macmillan Co., W. B. Saunders, and Freeman, Mr. Behnke has had nationwide contacts with scientists in many fields. The Association will make use of his background in developing and strengthening its relations with affiliated and associated societies, including the academies of science, and it is also planned to have Mr. Behnke take charge of the publication of the Association's symposium series.